What Does Weather Modification Need? A View from the Operational Level

THOMAS J. HENDERSON

Atmospherics Incorporated, Fresno, Calif. 93727

(Manuscript received 4 November 1977, in final form 31 January 1978)

ABSTRACT

For 30 years the field of weather modification has been struggling through a labyrinth of scientific, legal, societal, economic, legislative and operational paths which have produced a continuing controversy on the propriety of operations, the credibility of stated results, and the priorities of research. Such is the nature of our quest for knowledge and the ultimate application of new ideas. Weather modification is unique in that it deals with infinitely changing atmospheric parameters which are more difficult to predict and measure than the unknowns in most other disciplines. If a subject is poorly understood, it is always poorly explained and in the end more rigorously questioned by the uninformed. The present status of weather modification should be neither surprising nor discouraging to the point of rejection.

This paper explores some of the major problems at the operational level and discusses the interactions between applications and the other facets of our society which influence those engaged in operations. Some specific suggestions are presented on how we might find our way from the labyrinth to a clear path in the future.

1. Introduction

Weather touches individual people in more direct ways each day than any other single entity. As a result, most people are "experts" on weather. However, it is interesting that very few persons are admitted experts on cloud physics. In a room full of people, most are willing to discuss weather with substantial authority. However, if the term "cloud physics" is mentioned, the conversation shows considerable thinning even though it is the understanding of cloud physics which ultimately leads you to a more complete understanding of the weather.

For 30 years the field of weather modification has been struggling through a labyrinth of scientific, societal, economic, legal, political and operational paths which have produced a continuing controversy on the propriety of operations, the credibility of stated results, and the priorities of research. Such is the nature of our quest for knowledge and the ultimate application of new ideas.

Weather modification is unique in that it deals with infinitely changing atmospheric parameters which are more difficult to predict and measure than the unknowns of most other disciplines. If a subject is poorly understood, it is almost always poorly explained and in the end, more rigorously questioned by the uninformed. For this reason, operational weather modification now has a multi-faceted image. Many in the scientific community consider it a very uncertain technology. Large segments of our general society view it with suspicion and mistrust. The economists' viewpoints range from high value in certain agricultural areas to zero value in other sections of the world. The legal profession tends to focus on liability and political viewpoints range from "good for my constituents" to "hot potato"!

What weather modification needs at the operational level is a more definitive image. Because our societal interactions are as complex as the weather itself, an accurate and acceptable image will emerge only if its shaping is responsive to all segments of our society. This shaping can move forward on several fronts.

2. The scientific arena

Scientists have so far been unable to provide us with the credibility we expected in order to establish a stronger base for operational programs. Many of our thoughts at the operational level come about because of 1) hoping that scientific field experiments would provide operational programs with a strong credibility assist, 2) watching some scientists equate tunnel vision with objectivity when attempting to design and operate a field experiment, and 3) suffering through the impact of the proclaimed results from these field experiments on the credibility of operational programs.

In some instances, this credibility gap has been somewhat improved by exciting theoretical work plus results from a few well-designed field experiments such as the Florida Area Cumulus Experiment, the

0021-8952/78/0889-0894$05.00

Israeli Program and the North Dakota Pilot Project. On the other hand, the gap is sometimes widened by poorly designed field experiments and a loud voice or two within the scientific community which has emphasized the suggestion of a negative result. It is unfortunate that some scientists are willing to emphasize an apparent negative result on the basis of data they would consider inadequate for an expression of positive results if the sign of their data were reversed.

For some reason, many good scientists turn out to be less than adequate when it comes to operating a field experiment. What is often a startling and innovative idea for an appropriate experiment, often turns out to be a disaster when the scientist insists he personally transports his idea into the field, assemble the parts necessary to make it work, and proceeds to hold the supervisory reins while the idea disintegrates toward some worthless end point. What field experiments need is a strong input from operators who have extensive backgrounds of experience in the technical aspects of work in the field.

Historically, the good scientific discoveries and the applications which follow, have been turned in by people who *believed* in what they were doing. Very little in this world has ever been accomplished by anyone who is so objective about his work that he is unwilling to enthusiastically anticipate what he might discover further down the path.

Two suggestions might be helpful. First, those of us at the operational level need to be convinced by the scientists conducting field programs that they believe in their research and that a continuation of their program will eventually produce useable and beneficial results. Second, approaching a field experiment with cautious optimism or guarded pessimism is a traditional scientific requirement. On the other hand, at the operational level, it is refreshing to occasionally observe that rare and exciting trait called, "enthusiastic objectivity."

3. The general societal scene

The results from an artificially induced event are extremely difficult to identify, and even more difficult to accept, whenever a similar event is also produced by natural causes! This is one of the primary reasons for our present weather modification credibility problem. As viewed by the general society, the problem could well be called the "uncertainty factor." It is this uncertainty which neutrals and opponents use as the basis for a large part of their arguments, and this factor is loudly expressed by those who view scientific uncertainty as synonymous with such terms as unsuccessful, worthless or dangerous.

We live in a society where everyone has an opportunity to speak, with or without a strong data base. In this type society, where responsibility is not necessarily the primary factor in maintaining free speech, the chances for establishing reasonable credibility become less and less as the time increases before an unquestioned effect has been demonstrated. An acceptable positive effect must include some sort of identifiable fingerprint, for without this blessing from both the scientific community and the user-payer groups, there is little chance that credibility will ever reach an acceptable level.

Those who believe in weather modification as a useful and beneficial endeavor do not, as a rule, have at their disposal as many reasons for their belief as those who are opposed to programs. For the proponents, it is usually enough to believe the value of more rain or less hail is so great that any reasonable uncertainties about the results are worth the risk of limited identification. Of course, this usually carries the provision that research programs are in progress toward stronger evaluations and operational improvements in the long range.

For the opponents, a much wider range of beliefs is available to support their view. These beliefs can be generally itemized as follows:

1) Simply do not believe it works.
2) Strong religious views against such programs.
3) Believe they are directly and immediately being harmed by the products of the operation itself.
4) Question the environmental aspects which may develop from the seeding material or the product of the operation.
5) Question both the ethics and the advisability of "fooling around with Mother Nature."

Of course, these views are expressed by both those who make use of one or more of the above thoughts in order to avoid becoming an active part of any particular program, as well as by those who actually believe a particular rational and use it during active participation.

It would seem that education is the key, as it is in many such controversial areas. But how can we ever hope to decrease the uncertainty factor within any area as complex as the atmosphere when an uninformed public is schooled by an uninformed media whose livelihood depends, to a great extent, on sensationalized coverage and the preservation of controversy?

We are educated to believe that news is dull unless it transcends all that has happened before. Weather modification is no exception and it will continue at this level until many of us assist with the development of an active positive educational program at the national level. This will require many innovative approaches by the scientific community. It will also require active participation by the user-payer groups and contractors by providing substantial improvements in the design, operation and evaluation of field programs. It will be necessary to develop within the media a high sense of reporting responsibility.

We must recognize that many of our societal excursions are based on what we *perceive* to be so and not necessarily what *is* so. As long as persons are willing to react so strongly, even though the data base is weak, the chances of a quantum jump in our weather modification credibility remains slim. Education based on sound information is extremely important, and those who follow this route must be willing to express their views with the same certainty and volume level as those who shout a negative position.

4. The legal influence

Weather modification needs a legal beachhead. A view from the operational level indicates some cautious thrusts have been made toward this goal but we have not yet established a solid toehold which can be used as a platform for weather modification law. Proper law comes from an in-depth understanding of the overall subject. Perhaps this is the reason why we are presently awash. However, as new and deeper insights to the various weather modification components become available, then proper law is certain to emerge. In the meantime, the operational aspects of weather modification continue to suffer through a period of some "trial balloon" state statutes, questionably administered in certain cases by rather fractured rules and regulations.

Most of the state statutes have been developed through a series of evolutionary processes. In each case, the state has looked at the shortcomings of the previous efforts in other states and then developed additional and modified approaches which are intended to improve their own legislative behavior. The modifications are sometimes designed to address particular conditions within the individual state, but other times they are no more than simple political responses to opponents or proponents. Except in those states where weather modification has been deleted as an acceptable activity, there are no state laws which present insurmountable road blocks to serious programs at the operational level. Most are reasonable laws designed to insure that programs are conducted by qualified groups and competent people.

Although many state statutes contain very little beyond the scope of normal licensing and permit requirements, it is often the administration of these statutes under a set of rules and regulations which does produce a number of time-consuming responses of questionable value. In some cases, the rules and regulations can be administered in such a way as to delay the project operations for many weeks or even months. In other cases, the administration of the rules and regulations may take the form of a political or societal response, and essentially ignore many of the legal and scientific aspects. A recent case in Texas took nine months of deliberations before a permit was approved, even though the proponents developed a strong set of scientific facts relevant to the operations and the opponents were only able to develop their beliefs on the basis of emotions. Here again, we find that future decisions may be based on what is perceived to be so and not necessarily on what is indicated from all available data.

From an operational point of view, it seems apparent we urgently need new weather modification law. The emphasis should be on law, not laws! In part, new law should be based on our enormous bank of information which can be used to intelligently address the many questions and concerns. Although our knowledge is imperfect, and will always be so, it appears prudent to now develop innovative guidelines for weather modification law, particularly at the state level.

5. Evaluations—A dilemma

Why does anyone want an evaluation? The reasons fall into three primary categories: 1) because the program sponsor requires it; because 2) as an applied research or operational group, you would like to find out with some degree of certainty just what was accomplished; and because 3) if you really believe in weather modification as a viable water resources management tool, you would like to reduce the "uncertainty factor."

For more than 30 years, scientists and lay persons alike have been searching for some sort of utopian evaluation scheme which would once and for all set aside the uncertainty of results. The approaches have been monumental! A list of those which have been used in the past and are anticipated for continuing use in the future, probably in many modified forms, include the following:

1) Comparisons of data from operational periods versus historic records.
2) Data relationships between target and control areas.
3) Treated versus untreated convective cells, storm systems, or precipitation bands.
4) A wide variety of randomization schemes, plus many statistical methodologies.
5) Predictor systems which use various meteorological parameters.
6) Area-of-effect approaches.
7) The direct use of physical processes in the atmosphere.
8) Mathematical models which attempt to describe the complex atmospheric processes.

At the operational level, one of the most common questions is, "Why is it so difficult to produce a meaningful evaluation?" In simple terms, the many answers to this question can be reduced to the

following:

1) The extreme variability associated with any natural phenomenon and our inability to predict these extremes changes, particularly the atmospheric processes.
2) The magnitude of the fingerprint we are attempting to impress on this highly variable atmospheric system is small compared with the total system itself and often well within natural variability.

It is fairly obvious that traditional evaluation methods have not been totally successful in leading us out of this dilemma. However, the picture is not altogether bleak. Past evaluations have provided strong suggestions of operational success. It has been these early evaluations, limited as they were, which gave us the courage to move ahead with longer range programs in the field.

In the end, any approach to evaluations must address the question, "Who are we trying to convince and what level of proof do we need to convince them?" In the scientific arena we spend most of our time trying to convince each other. In the operational area, we put forward a lot of energy trying to convince the user-payer groups and the general public. A view from the operational level indicates it would be useful if these two energy sources were somehow merged.

6. Some political aspects

Weather modification in the United States could use some political fresh air! A few state governments have led the way toward applied programs on a larger scale than individual operations, but none have consistently and aggressively declared themselves as strong proponents. The federal government has not yet established weather modification as one of its visible national goals. This is an important fundamental consideration when discussing any aspect of operational weather modification in this country. Like it or not, federal and state government inputs in the form of programs and political attitudes, have an extremely strong influence on weather modification operations.

When federal and state programs appear successful, the proponents of operational programs quote them at length. When these programs appear confused, or the results are proclaimed inconclusive, the weather modification opponents are delighted and voices are loud. As a result, many of the current weather modification decisions at both state and federal levels have had strong political overtones. It is easy to see why legislators viewing weather modification as an imperfect technology, with results difficult to identify, sometimes express their views on the basis of political expediency rather than on the basis of potential economic benefits or scientific credibility.

Atmospheric processes recognize no political or geographic boundaries. For this reason, the political processes which will address weather modification in the future must deal with the problems on the basis of the atmospheric processes themselves. Getting a firm mental grip on this concept may actually be well beyond current political mentality. However, it is a concept which must be addressed if we ever hope to move weather modification operations from geographic boundary oriented thinking to the more rational acceptance that atmospheric processes are in constant motion and need to be treated with considerable political understanding and cooperation.

7. The need for research

Operational programs require a strong interface with meaningful research programs. There are no business-oriented groups today who disagree with this high priority requirement of research and development programs. From an operational view, the areas of concern are largely related to the following:

1) Who are the decision makers responsible for organizing and implementing the research and development programs?
2) What people and what groups will be in charge of actual research and development operations in the field?
3) Are the research and development programs realistic and can the anticipated results have an immediate and direct input to national needs?
4) Will the funding levels be sufficient and contain the stability necessary for the periods required to reach the prestated specific goals?

So much of our national research effort has lacked a common bond with the potential beneficiary of the actual research. In the case of weather modification, the gap between researcher and the user-payer has been as wide as the one generated by nuclear energy concepts. In the near future we must close this gap! The overall research energy focused on weather modification should not be diluted either by ineffective research which has no clear applications goal or by poorly designed operational programs which have not considered recent results from relevant research.

8. The liability problem

Liability within weather modification operational programs has two specific categories. These are 1) general liability relevant to the operation of equipment such as aircraft, project vehicles and cloud seeding devices, and 2) specific liability covering the *results* from cloud seeding.

The first category offers no anticipated problems beyond those associated with any general liability exposure. Weather modification operations have not

produced any significant increase in general liability cases anticipated to come from airplanes crashing into buildings, people burning their hands on cloud seeding devices, or project vehicle involvement in frequent accidents. Accordingly, the rates for insurance in this general liability category have followed the same course as insurance covering general liability within most segments of industry.

In the case of specific liability covering the results from cloud seeding, the *perception* of what may happen in the future is a strong consideration within any operational program. A law suit for damages is possible from anyone who feels he has been harmed. For two reasons, the likelihood of a judgment in favor of the plaintiff is small. First, the overwhelming evidence which has emerged from a long list of operational programs all over the world indicates that no significant harm has resulted from any operational program. If any harm has actually been produced, it has not been identified to the satisfaction of any court. Second, the extremely wide variations in natural phenomena do not permit an easy identification of the fingerprint placed on any natural event by the operations themselves.

Liability insurance covering the results from cloud seeding has been available for many years. As proof of one's ability to respond to people who may perceive they have been damaged, this type of insurance is mandatory as part of the rules and regulations of some states. From an operational point of view, the liability aspects of weather modification have taken a more serious turn in the past few years, even though no claims by plaintiffs have yet been successful. A portion of this more serious view is related to the expanding areas of operation within the country. As the areas enlarge, there is a corresponding increase in exposure to possible claims. However, there has been no increase in the belief that plaintiffs may actually be awarded claims for damages. The concern is with the cost of defending such a suit which, in turn, is the primary reason why this specific liability insurance was developed.

A view from the operational level indicates a strong desire to address the problems of liability at a much higher level than presently available. For example, it seems prudent for the federal government to accept responsibility for the liability exposure in those programs which are funded by the federal government and largely controlled by personnel from the relevant agency. In the case of state/county funded programs, the responsibility may be less obvious. Except for a few cases, these type programs are usually operated and controlled by contractors who have little daily input from the state or county agencies except through normal administrative tasks, reporting functions, and operational decisions dealing with actual weather conditions at various local levels within the operational area boundaries.

One point is clear! The future aspects of weather modification liability will certainly increase as operations become more widespread and the general public becomes more knowledgeable about our attempts to place further fingerprints on an already modified atmosphere.

9. Summary—What do we need!

The gap between scientific proof and apparent results from operational programs continues to influence the "uncertainty factor" in the mind of the general public. Steady progress is being made to close this gap but it has been a slow and frustrating time. The technology needs the attention of good scientists with enthusiastic and innovative approaches to weather modification at all levels.

It is unlikely that people who work from a limited data base and perceive something to be so, will disappear from this scene or remain silent until their data base expands and gains strength. For this reason, we need to dramatically increase our educational efforts to provide completely open programs at the operational level and continue to acquire operational data which are factual, objective and accurately represents the overall content of each field program. We must work with the media to assist with these education programs.

The legal aspects of weather modification have not yet reached a level where operational programs may be threatened by insurmountable road blocks. As a general rule, operational programs have found little difficulty in conducting field activities within the framework of state and federal laws. The administration of rules and regulations at the state level continues to be a problem whenever political expediency becomes the foundation for decisions. New weather modification law is coming and it will require the acceptance of ideas which may not be found in our present approaches to water law. For example, it is likely that future atmospheric water law will be quite different from surface water law which embodies riparian rights.

Evaluations of weather modification activities have been one of the most frustrating aspects of operational programs. Strong evaluations are still difficult to organize, particularly in operational programs where the primary objective is to take advantage of every weather event and leave none for real-time controls. The divergent nature of atmospheric processes compound the evaluation problems. The concepts of science and the rationale of user-payer groups must somehow be merged to produce answers which have at least some mutual acceptance.

The atmospheric processes do not recognize political or geographic limits. Decisions of the future must recognize the existence of these processes before we

can ever hope to move away from decisions which primarily come from a political base without regard for their effect at the operational level. We must recognize that the atmospheric processes are in motion and regulations which have relevance to these motions must not be geared to fixed boundaries.

Meaningful research programs can and should have a strong interface with operational programs, just as operational programs must look to research efforts as a basis for improved project designs and stronger evaluations. A mutually cooperative process will certainly produce the most useful results.