

By

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Background

Research efforts directed toward the development of a weather modification capability in South Dakota have been underway for approximately 10 years. South Dakota School of Mines, Institute of Atmospheric Sciences, has been active under the sponsorship of the Bureau of Reclamation since 1963. Their program has considered a broad range of problems both in the laboratory and in the field. Their activities have encompassed hail suppression research and rain increase experimentation, and involved scales of both individual cloud size and areal applications. The results of these research efforts led in 1968 to the development of a pilot project in North Dakota to test the applicability of the results on an operational basis. Specific results from their areal testing programs indicated that increases of 10 to 20 percent could be achieved during the growing season, which in the case of South Dakota amounts to one to two inches during the period from May 1st through September 1st.

The efforts of the Institute of Atmospheric Sciences researchers reinforced and quantified the results obtained by locally sponsored groups operating on the basis of production of additional water or hail suppression only. These early efforts began in the 1950's and included varying degrees of evaluation. Since the projects were funded by voluntary contributions during the early part of the 1950's, very little emphasis was placed on evaluation. More emphasis was placed on actual operations to produce additional rainfall.

Following the early voluntary efforts, more organized activity took place under county sponsorship. This became possible through the passage in 1963 of a law which permitted counties to support weather modification activities on the basis of a tax levy on assessed property valuation. This was done on an individual county basis, and occasionally multi-county projects would develop as a result of cooperative agreements. Based on previous records of the degree of this kind of activity, an average of one hundred thousand dollars per year was spent by individual counties over the roughly nine year period. The 1971 funding level was approximately one hundred thousand dollars by seven counties.

An informal evaluation of these county sponsored efforts was made by Marion N. Bruce of the South Dakota Weather Control Commission (WCC). He noted in his evaluations consistent increases by the various county efforts. His method of evaluation involved target and control comparison using long term precipitation means. In 1971 a more organized effort to evaluate these studies was conducted by the Weather Control Commission. A contract was awarded to the Institute of Atmospheric Sciences, South Dakota School of Mines, to evaluate the county projects, again using target and control techniques. They noted, as a result of their study, that increases in precipitation were shown for all four of the county projects active in the state during that summer season. Assuming that there was independence of events, chances of increases in all four projects occurring naturally were of the order of one in 64.

The results of all these efforts, both research and operational, by the counties led to legislative action at various times. In 1953 the basic weather modification law which established the Weather Control Commission was passed by the state legislature. In 1963 a law to permit counties to levy up to one mil general tax on assessed valuation to support weather modification was passed. Enabling legislation for a statewide program was passed in 1971. This legislation also included an appropriation of an adequate amount of money to provide for the design and establishment of a statewide program during the first year. In 1972 the legislature passed an appropriation for initiation of the statewide program on a limited scale.

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Organizational

Preliminary indications in 1971 were favorable to the establishment of a centralized state activity. The basis for this state activity is the Weather Control Commission whose structure involves a broad range of functions and activities. These functions and activities are set by law, and are provided with the assistance of advisory groups of a technical and non-technical nature. The organizational structure developed to provide for all of the functions required is shown in Figure 1.

The Director of the Weather Control Commission is responsible to carry out a statewide program of weather modification to provide an economic benefit through rain increase and hail suppression. In the development of an organization to accomplish the responsibilities for such a state program, it became apparent that it would be desirable to develop the effort on the basis of a cooperative state and local program. This desirability was indicated both by attitude studies conducted by various sociological groups and by experience on previous programs. It was indicated that local state cooperative efforts would be desirable not only for decision-making but in the funding of such programs. Local participation in the program is based on the county structure. There are several reasons for this organizational arrangement. Primarily the counties have the authority to fund weather modification programs on a tax levy basis. This then provides for the cost-sharing aspect of the organizational program. In addition, the use of county organization provides for participation by elected officials who are in contact with local groups and individuals throughout the entire program. Further, the local organization makes use of advisory services from various farm related organizations such as Conservation Districts, Soil Conservation Service and Extension Service, in order to provide for observations and advice on the operation of the program from the standpoint of farm operations.

The specific project organization based on the cooperative state local concept is developed on the basis of a number of physical and sociological criteria. The physical criteria was based on both agricultural practices and weather modification technological capabilities. It became readily apparent that the decision regarding the weather modification operations in a particular area would need to be somewhat uniform or at least represent a general sort of a criteria. For example, decisions in a particular area are easiest to make for homogenous crop patterns. Therefore, the state was divided into a series of areas in which cropping patterns were essentially similar and for which uniform weather modification decisions could be made. It became readily apparent when the topography and climatology of the state were studied that the cropping patterns and agricultural patterns are quite different from one end of the state to the other. Therefore, it was important that the projects that are developed be in tune with the needs and desires of a particular area.

From an equipment and technological standpoint the size and shape of the various areas or districts, as they became known, to be developed were dependent upon the capabilities of the aircraft and radar proposed for use in the project. For example, the standard meteorological weather radar system that is available commercially has an effective range of about 50 to 60 miles. Utility class light aircraft travel at speeds permitting coverage of 75 to 150 miles within the time scale feasible for successful convective cloud operations. The final result of the various criteria that were developed was a concept of multi-county weather modification districts. These districts were designed on the basis of county boundaries to fit roughly within a 100 mile diameter circle. Within that circle an administrative and technical organization was developed on the basis of local-state cooperative efforts whereby participation by an individual county was requested by county commissioners. Figure 2 portrays the districts active for the 1972 season.

Program Status

Funding for the program has been obtained from various sources. By legislative appropriation the state general fund will provide \$250,000 for the support of field activities during the 1972 summer season. This funding represents 75% of the cost of operation. Local support for funding from counties will amount to approximately \$100,000 during the 1972 season. These monies are developed on the basis of tax levy and they represent approximately 25% of the total cost of operations. Total state and county funding for 1972 represent support for phase one of the program which treats approximately one-third of the state.

Federal support has been indicated from two federal agencies. The Bureau of Reclamation and the National Oceanic and Atmospheric Administration are both participating in some aspects of the program. This support is provided primarily in the form of services and must be used for research and evaluation purposes. None of the federal funds can be used for the operational aspects of the program.

Development of the program is based on a phase or stepwise approach with partial coverage during the 1972 season. Phase one during the 1972 summer season represents partial scale activities. A total of 38 counties have requested participation in the program. Of these 38 counties a total of 21 will be included in the form of Districts I and II. Three other districts have been organized, and are currently awaiting participation in the program during the 1973 summer season.

Invitations to bid on contract for services for 1972 were sent in February. These invitations to bid included contract services for radar, aircraft and personnel needed for the various project areas during the summer. The invitations were sent to approximately 26 individuals and firms. Bids were received based on these invitations on March 6, and a point rating system was used to evaluate the successful bidders. This point rating system and the point awards were reviewed by a committee on March 8th, and contracts were subsequently awarded.

Personnel for the operational program will be provided directly from the Director's Office of the Weather Control Commission and by contract. It is anticipated that the State Director's office will consist of a small staff of technical and supervisory people. Currently a Director and Assistant Director comprise the professional staff, a contract supervisor is anticipated for field work and a secretary completes the staff.

The field operations staff will be provided for by contract. This staff will consist of a District Meteorologist, who is the key man on the working team, a radar operator and three pilots to man the aircraft in each district. Experience has been stressed heavily as being the key to all staff members during this first year.

Advisory assistance for the program will be obtained from various agencies. The Bureau of Reclamation has provided advisory assistance both directly through its staff and by means of the time share computer system that is being provided to the field project. The National Weather Service is providing assistance both directly in the form of radiosonde observations at the Huron Weather Station during the month of May and through a grant to the Institute of Atmospheric Sciences to develop radar evaluations of weather modification activities. Additional advisory assistance and observations are provided by local farm and county groups within the target areas.

Proposed Operational Procedures

State level activities will be concentrated on the general aspects of the state-wide program. For example, the initial design and specification for project operations has been developed by the Office of the Director. This design consists of uniform criteria and equipment for each individual district. The Director's Office also provides coordination for interdistrict cooperation whenever weather systems are common to more than one district. In addition, the State Director's office provides for all contracting activities. In this way single contracts for all radar and aircraft and personnel are awarded. Contract performance monitoring is provided by the State Director's office. Testing will be accomplished to determine if criteria for contracts are followed. Finally, the State Director's office will provide for communication activities. This is particularly important where interdistrict activities are required. In general over-all supervision of all activities will be by the State Director's office.

Field operations themselves are carried out by contract personnel. Seeding activities are conducted on a 24-hour-a-day, seven-days-a-week basis, and the individual seeding events are directed by the District Meteorologist. Thus, the importance of having experienced personnel in this position is apparent. The activities will involve both rain increase and hail suppression, and the primary emphasis of the seeding will be on cold cloud activities.

Assistance from the State Director's office for daily field operations will be provided to the districts in the form of forecasts on a twice daily basis. These forecasts will specify seeding occurrences and use models to indicate the various different modes and types of activity. This forecast service is provided on a contract basis through the Institute of Atmospheric Sciences of the South Dakota School of Mines. In addition the State Director's office is working through subcontract to develop conceptual models which will portray seeding conditions. In essence these conceptual models will be based on research results available to date, and will specify the criteria used to define seedability of occurrences. These conceptual models will also include information from the various computer models used to define seedability.

A communications network will be developed with primary emphasis on a telephone link between the various stations and sites. Also there will be a project radio system in the VHF band to provide for communication both air to ground and air to air during the seeding operations.

The State Director's office will supply seeding materials under a bulk order contract. The seeding materials consist of silver iodide-ammonium iodide-acetone mixes and cloud seeding flares. All project aircraft are equipped to dispense both types of material.

Local cooperative assistance is required from the various participating county groups. In each District a Coordinating Committee for decision-making concerning general policy has been developed. These Coordinating Committees consist of a representative from each of the county commissions from participating counties. These Coordinating Committees will be responsible for decisions regarding starting and ending dates of the program, cost proration for participating counties and seasonal restrictions resulting from excessively wet or excessively dry conditions. These local cooperating groups will also provide data collection assistance from various sources. Farmer cooperators are being asked to make precipitation measurements and provide hail measurements. In addition agency support from the Extension Service, Soil Conservation Service, State Conservation Districts and similar groups is anticipated. The period of operations for the program will be from May through August 31, during this first season.

Evaluation

Physical evaluation of the program will be undertaken to determine precipitation or hail effects. This will consist of a climatological approach using historical records, and will be developed in the form of a target and control relationship. The target and control relationship will be reinforced by a comparison of seed, no-seed events that result from operational restrictions or restrictions due to unseasonable weather, such as excessively wet conditions. Real time evaluation of radar data will also be included as a supplemental technique.

An economic evaluation of the effect on crop production is under way. This will involve development of a model in the form of a statistical regression to predict and detect changes in crop yield as the program progresses. This work is being conducted on a subcontract basis with South Dakota State University.

Evaluation of sociological effects will also be a continuing part of the program. This will involve data collection and analysis to sample people's attitudes toward weather modification and what shapes those attitudes. Part of this project will be accomplished by in-depth surveys to develop the pertinent data bank. The activities will investigate background information on previous studies as well. The sociological studies will continue on a monitoring basis during operation.

Environmental effects will be monitored in conjunction with other studies conducted with South Dakota State University group. It is anticipated that analysis of silver in precipitation samples will be conducted in the future. A sampling network will be developed during the current year. These activities will be conducted also on a subcontract basis with South Dakota State University.

Special Studies

A series of special studies to determine various extra-area effects and sociological effects will be conducted in cooperation with other groups. A downwind effects study on a regional scale will be conducted as a cooperative effort with the National Oceanic and Atmospheric Administration (NOAA). Currently this program is being proposed by NOAA for contract with other researchers. The statewide effort in South Dakota will serve as a basis for these studies, since the seeding on the large regional scale will be used to provide the basic input for possible effects.

Sociological studies in cooperation with the Institute of Behavioral Sciences of the University of Colorado have been underway since January of 1972. At that time a baseline study to collect data prior to seeding effects was completed. Supplemental baseline information was gathered in April of 1972. This program will continue on a monitoring basis to determine changes in attitudes as the program progresses.

Conceptual models will be modified and revised as information becomes available. This work is being done on a subcontract basis with the North American Weather Consultants, and is expected to provide the basis for decision-making criteria in the field. These models will also provide a useful basis for stratification for future evaluations.

One of the most important aspects of the program will be the development of educational programs by which the general public is informed of the status and progress of the program. These will be developed to provide up-to-date information as the program progresses. They will consist of general weather modification information regarding the status of the field as a whole and specific results of weather modification activities of the South Dakota program.