THE WEATHER MODIFICATION RESEARCH PROGRAM OF THE RANN DIRECTORATE OF THE NATIONAL SCIENCE FOUNDATION

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I. BRIEF HISTORY

Following the recommendation of the Advisory Committee on Weather Control, created by Congress in 1953, Public Law 85-510 of July 11, 1958, directed the NSF "To Initiate and Support a Program of Study, Research and Evaluation in the Field of Weather Modification". A new program in Weather Modification was promptly established at NSF with FY 59 expenditures in excess of one million dollars. The NSF program provided a full range of theoretical studies and laboratory and field experiments.

A history of NSF funding for Weather Modification is shown in Figure 1. Important field experiments supported through this funding period include Project Whitetop and the Climax Experiments. Project Skyfire and Project Stormfury were both initiated under NSF support and significant support has also been contributed to numerous field programs, both research and operational. The substantial growth of funding support since 1970 is largely associated with the National Hail Research Experiment which currently absorbs about half of the annual budget.

In 1972, the Weather Modification Program was transferred from Basic Research to the Applied Research Directorate (RANN) and became a part of the Division of Environmental Research and Technology. There are two major changes in program philosphy brought about by this move. The program has become more broadly viewed in the context of managing and protecting our environment. Secondly, the program has become more problem-oriented with an emphasis on the near term utilization of research results, in accord with the objectives of RANN. This has emphasized the applied aspects of Weather Modification and the program was immediately used as an example of the RANN concept of taking an existing technology and accelerating its utilization. At the same time, basic research in areas such as nucleation were eliminated from the program. Presently, at least a part of this has been picked up by the Meteorology Program and there is considerable coordination between the two programs to insure that the basic research areas related to weather modification are adequately covered. The budget figures in Figure 1 also represent only the RANN budget and not the supportive efforts efforts in the Meteorology Program and others. For example, facility support of $1.0-1.5 million annually has been provided to NHRE. Thus, the total budget for weather modification related research at NSF is much greater than shown in Figure 1.

II. OVERVIEW OF CURRENT PROGRAM

The current NSF Weather Modification Program is very broad-based but

certainly not all-encompassing. It deals with a wide range of specific, critical research topics. These will be discussed according to subprogram elements.

A. Weather Hazard Mitigation

Objective - to establish the feasibility of mitigating the undesirable effects of selected weather hazards and to improve the technology for mitigating these effects.

National Hail Research Experiment (NHRE)

The overall goal of NHRE is to determine the potential for suppressing hail damage by cloud seeding and to determine the extent to which hail suppression can be accomplished effectively on an operational basis.

A National Research plan for hail suppression was initiated by NSF in 1965 following the recommendation of the Interdepartmental Committee for Atmospheric Sciences (ICAS). Authorization was given in 1969, for support of a 5-year project to begin in FY 72. A field Experiment was conducted during the summers of 1972, 1973, 1974. There was no suppression experiment in 1975 and none is planned in 1976, to permit a more complete analysis of prior data and to evaluate the status of the project. This evaluation has pointed to the need for design alterations and the project is currently considering a redesign and conducting highly focused field research to enhance the new design. The future of NHRE will be largely determined by the adequacy of a new design and the continuing priority placed on hail suppression as a national need.

Lightning Protection

The research objectives of a study on lightning protection and thunderstorm electrification include: 1) investigation of the anomalous behavior of lightning around elevated structures and development of improved means of lightning protection 2) determination of the effects of lightning on precipitation rates in thunderstorm clouds and 3) development of techniques to trigger lightning from thunderstorm clouds.

Wind Shear Warning

Recent airline accidents have pointed to local wind shear phenomena as a major hazard to avaiation. In many cases strong wind shear occurrences have been associated with the gust fronts of severe thunderstorms. The research experience from participants in both the NHRE and METROMEX is being drawn upon to better describe the characteristics of severe thunderstorm gust fronts and to develop both airborne and ground-based warning systems for detecting the presence of local wind shear.

Fog Hazard Alleviation

Although there is presently no research in fog, there is a continuous need for fog mitigation as it presents a serious hazard to both aircraft and automobile transportation. In addition to natural fog occurrences, there

is a need to investigate the possible reduction of local fogs produced by urban, industrial and agricultural sources.

B. Inadvertent Weather Modification

Objective - To delineate the cause, extent and impact of inadvertent weather modification and to subsequently develop ways to use land and energy resources to achieve more desirable responses in weather and climate.

METROMEX

A cooperative field research effort in the St. Louis area which investigates urban-industrial influences on the surrounding weather and atmospheric conditions. This project began in 1970 and is in its final year with plans for only a limited field study this summer. The major emphasis will be given to the analysis and synthesis of data for the Final Report. Preliminary results show significant increases in both precipitation and severe weather downwind of the city. Economically the value of the increased water for agriculture far exceeds the agricultural loss produced by a more than threefold increase in hail damage. Both land use change and man-made emissions contribute to the total urban effect. Alterations in the radiation and energy budgets and the airflow produced by changing land use have been shown to effect large convective storms; alterations in the concentrations of CCN, large hygroscopic nuclei, and ice nuclei change the structure and characteristics of urban influenced clouds but have not yet been directly linked to the precipitation process.

Other and Future

METROMEX provides the basis for numerous future studies in the area of inadvertent weather modification. Specific processes in most cases require better delineation. The transferability of results must be examined by both field measurements and models. The extent of downstream effects must also be examined. There is a need for exploring both highly concentrated sources such as industrial parks and energy parks as well as large-scale land use changes.

We are presently supporting a study of the influence of widespread irrigation on the climate of the Great Plains. The primary objective is to determine the effect on precipitation with secondary considerations of effects on other meteorological parameters. Preliminary results indicate the presence of rainfall anomalies in the irrigated areas during wet, summer months only.

The interests of the weather modification program are being combined with those of the trace contaminants program to formulate a research effort addressing the problem of acid rainfall. Research interests include the formation, transport and environmental impact of acid precipitation. If negative impacts are significant an important aspect of the research would deal with methods of mitigating the problem. Preliminary studies in acid precipitation will begin in FY 77 with plans for a structured research effort beginning in FY 78. In the long range the total impact of the megalopolis on large scale weather processes and climate becomes an important consideration.

C. Technology and Evaluation

Objective--to develop an improved capability to design, perform and evaluate weather modification experiments. The rapidly increasing cost of AgI together with continuing concern for long term detrimental effects of heavy metals on the environment form the basis for the search for new cloud seeding materials. Laboratory studies have shown that efficient ice nucleants can be produced by coating certain inert powders with AgI. Several organic materials have been shown to be effective ice nucleants. These materials are biodegradeable and can be produced at a fraction of the cost of AgI. Research continues in the development of delivery systems for organic nucleants.

A major obstacle to successful field tests of weather modification technology is due to the great natural variability of atmospheric processes. This variability has led to the demand for long, costly experiments. One of the highest priority research areas in weather modification involves the combined use of predictive models, advanced measurement systems, and statistical analysis to improve experimental design and evaluation. Such improvements will aid in the logistic design of an experiment, and will reduce the predicted natural variability of weather events so that there will be an overall reduction in time required for conducting a definitive experiment. All of these aspects are being investigated in the NHRE. Inert tracers are being used to assess the effectiveness of AgI as a seeding agent in the Nevada Pyramid Project. NSF supported analysis of data from the Florida Area Cumulus Experiment has contributed to critical improvements in the evaluation of these data.

The considerable data available from the various commercial cloud seeding programs, some extending over several decades, offer a continuing challenge to develop more sophisticated methods for evaluating non-randomized seeding projects. New techniques developed for the evaluation of convective precipitation in METROMEX are promising. The development of other innovative methods is strongly encouraged in this area.

D. Societal Utilization

The implementation of weather modification technology is largely constrained in its acceptance by society. The problem of societal acceptability is as old as the technology.

Objective - To provide the social science interface of weather modification with society with emphasis in two areas:

- evaluation of the societal impacts of weather modification
- determination of goals and objectives which are best aligned with National Needs.

A study group formed at the request of ICAS is currently completing a three year study on the Societal Consequences of Weather Modification. The results of this study will be used by ICAS and NSF to identify areas where alterations or redirection in the Federal Program shall be made to meet major societal goals.

Contributions to the impact of weather modification on society extend across the disciplines of political, social, legal, economic, ecological and physical sciences. Research studies have been and will continue to be supported in all of these areas. Barbara Farhar and Ray Davis have touched on some of the social science and legal aspects. Studies of the environmental impact of AgI and other seeding agents continue. Economic studies of weather variability and weather hazards are being carried out for agriculture and other basic human activities.

A problem that impacts the entire societal area is the growing evidence for weather modification effects extending great distances downwind of the intended target areas. Analyses of data are consistently showing precipitation increases and levels of statistical significance for large downwind areas that equal or exceed those found in the specific targets. There is a continuing need for research in this problem.

E. Support of Agriculture

A new subprogram is being developed which emphasizes agriculture applications of weather modification. Primary objectives of this program element are to:

1. Develop a better understanding of weather variability and its significance to food production.

2. Reduce scientific uncertainties of weather modification and develop specific applications of the technology as it relates to agricultural needs.

An initial grant was awarded to the National Academy of Sciences to study the changing weather and climatic patterns and their effect on agricultural and renewable resources productivity. Included in this study is an assessment and evaluation of weather modification technology and its potential impact on agricultural production.

As a part of this assessment a workshop was held in Ft. Collins, Colorado last July dealing with the present and future role of weather modification in increasing agriculture production.

This subprogram will consider a wide range of research areas including - definitive investigations of the economic value of weather modification, studies of radiation and temperature control by cloud enhancement and suppression, innovative concepts for alteration of the microclimate, improve procedures for drought mitigation, etc.

III. FUTURE OF NSF WEATHER MODIFICATION PROGRAM

The National Science Foundation is a grant awarding agency. There is no in-house research. The Weather Modification Program is totally built upon the efforts of the academic, research and commercial communities. The vigor of this program depends on your ideas, innovations, successes and criticism. Increased Federal support for weather modification (at NSF and elsewhere) will only come about by convincing demonstrations of progress and promise.

In spite of continued recommendations from expert panels and authoritative reviews that Federal support for weather modification should be increased 5 to 10 fold, funding has at best remained level.

For the present, however, increased support will be a slow, gradual process. Within the NSF program there appears to be no constraints to such increases. Funds are allotted, at least in part, according to proposal pressure. Scientifically sound proposals on priority research topics are needed as well as conscientious, thorough peer reviews. Proposals are sought from both the university and private sectors. The RANN Directorate, in fact, is required by Congressional Directive to direct a minimum portion of its budget to Small Business. In Fy 76 about 15% of the total RANN budget will go to industry, one-half of this to small business.

Finally, let me echo Gene Bollay's statement that one of the important activities of the WMA should be the discussion of national priorities and goals. This group can offer valuable user oriented recommendations to NSF and other Federal agencies.

FIGURE 1

HISTORY OF WEATHER MODIFICATION FUNDING

FISCAL YEAR	TOTAL FEDERAL (MILLIONS OF DOLLARS)	NSF (MILLIONS OF DOLLARS)
1959	2.8	1.1
1960	2.5	1.4
1961	2.5	1.5
1962	4.6	1.3
1963	2.8	1.3
1964	3.5	1.6
1965	5.0	2.0
1966	7.0	2.0
1967	9.9	3.0
1968	11.3	3.0
1969	11.6	2.5
1970	12.8	2.8
1971	15.0	3.2
1972	18.7	4.5 RANN
1973	18.3	5.2 RANN
1974	13.5	3.7 RANN
1975	12.4	3.9 RANN
1976	14.1	5.0 RANN

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