# ANNUAL REPORT

TO

NATIONAL SCIENCE FOUNDATION

FOR

HAIL EVALUATION TECHNIQUES PROJECT

NSF GRANT GA-482

prepared by

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May 31, 1967

Illinois State Water Survey
Urbana, Illinois

# INTRODUCTION

This report covers the grant period of June 1, 1966 through May 31, 1967. The major activities of this first period have concerned 1) obtaining and training the necessary project personnel, 2) gathering of various types of historical hail data, 3) getting all necessary equipment and hail observation sources ready for data collection in 1967, and 4) two months of data collection.

The principal purpose of this project is to collect and analyze various types of Illinois hail data with respect to their ability to be used in evaluating any future hail modification experiments. Such data and the results will also have value in suggesting proper designs of hail modification projects, as well as providing a wide range of basic information on hail.

This project consists of four phases: 1) radar-hail comparative investigations using past data and that measured in the 1967 and 1968 hail seasons; 2) climatological-statistical investigations of historical hail data; 3) development of hail recording instruments; and 4) studies of surface hail patterns using various types of data. Analysis related to each phase is in progress, but it would be premature to present any results at this time. Extensive data has been collected on 27 hail days in April and May 1967. In this report

the major activities accomplished under each phase are described, and the personnel involved in the project activities are listed in the final section.

Radar-Hail Investigations

A large portion of the project activities to date have concerned this phase of the project. This work has largely concerned renovation and modification of the two radar units available for this study, and the initiation and organization of all potential sources for providing surface hail data for the comparative analysis. Of course, these surface hail data will serve as input into the fourth phase of the project, and are described under phase 4. The radar study area includes all of Illinois within an 80-nautical mile radius of the radar installation at the Survey's Meteorology Laboratory located 6 miles south of Champaign-Urbana.

The CPS-9 (PPI) 3-cm radar has been renovated with the installation of a replacement antenna drive system and a new electronic control system to provide the gain-step and antenna tilt operations required for the echo-reflectivity analysis planned. This radar data will be used to ascertain what percentage of all echoes with high reflectivities at various heights are associated with surface hail. The CPS-9 radar was operational on April 16, 1967. Scope photographic data

have been collected on 27 days, and on 18 days hail has occurred within the study area. Approximately 140 individual hailstorms have occurred in the area during this period and a large amount of useful PPI radar data has been collected. Most of this radar data will be directly transferred from film to punch cards using an Oscar chart reader to measure the echo outlines. A computer program under development will map for each echo the areal extent of the various reflectivity levels at different elevations. The surface hail data will also be fed into the computer and the program will identify and plot the hail occurrences that are associated with high reflectivity echoes.

The TPS-10 (RHI) 3-cm radar is being reconditioned with rebuilt antenna drive systems, a new radar console, a new scope camera, and new electronic controls including gain-step controls. Failure to receive an encoder on schedule will prevent placing the TPS-10 in operation until July 1, 1967. Temporary operation with manual controls will be initiated on June 7, 1967. The primary purpose of the RHI radar-hail study will be to discern any echo characteristics that identify storms which produced surface hail. Among the characteristics planned for analysis are the elevation of first echoes, growth rate of echo tops, growth downward of high level echoes, echo volume at various elevations, maximum echo tops, and duration. These echo characteristics will then be compared with those from non-hail producing storms on the same day.

As a part of this radar investigation, all past RHI film records available in the 1953-1965 period have been carefully scanned for dates with hail within range of the radar. These dates within this 13-year period were identified from crop-insurance records and U. S. Weather Bureau hail records. Attempts have been made to identify all echoes known to have been hail-producers with attention given to obtaining complete life histories of these storms. To date, 28 such echoes have been discerned and are being studied.

Climatological Investigations

The purpose of this phase of the project is to provide various statistical measures of the natural variability of surface hail over various sized areas and for different periods of time. Results will be presented in various formats designed to match potential seeding experiments as to statistical design, size of area, and duration of experiment. Two forms of historical data have been collected and are currently under analysis.

In five areas of Illinois, groups of Weather Bureau first-order stations and cooperative substations, each with 30 years or more of reliable hail-day records, have been identified. One group is composed of 4 stations in a 500-square-mile; three other groups of 5 stations each from three different 1000-square-mile areas, and another group of 8

stations forms a 3000-square-mile area. These data are currently being computer-analyzed to establish statistical measures of the variability in each area for the number of summer and annual hail days in 1-, 2-, 3-, 5-, and 10-year periods. Final results will be presented to show the frequencies of hail days and durations of experiments needed to reveal significance for continuous types of seeding programs, for target-control type of seeding approaches, and for random seeding experiments.

The second form of historical hail data to be studied consists of 20-year records of daily crop-hail insurance losses in Illinois. Four different regions having areas ranging in size from 1000 to 4000 square miles where liability has remained uniformly high have been identified. The daily data (dollar losses and percent crop damage) for these various sized areas will be analyzed in much the same manner as described for the Weather Bureau hail-days data. Detailed listings of individual paid losses in Illinois over the 1948-1967 period have been provided by the Crop-Hail Insurance Actuarial Association, who is sponsoring portions of this research. The data on these listings pertaining to the four regions of high liability are being identified, separately listed, and will be entered on punch cards for the subsequent statistical analysis. Since the amount of crop-loss is one of the most likely means of evaluating the results of a hail

modification program in well developed agricultural areas, the results obtained from the analysis of this uniquely long and detailed sample of crop-loss data should provide very meaningful information.

Hail Recording Instrument

The third phase of the project concerns the development of hail recording instruments for installation in field networks where hail modification experiments are planned. The purpose of this research and development is to produce an instrument that will record each hailfall occurrence and furnish quantitative data on the hail characteristics.

To properly design such instruments, past hail data collected from a series of detailed field studies of Illinois hailstorms were carefully reviewed. In addition, an elaborate questionnaire relating to needs for hail instruments was prepared, and answers were secured from 30 hail scientists. From these answers and the study of the detailed hail patterns and their surface characteristics, it was concluded that hail gages for hail modification programs would need to record a value for each hailfall that would equate to crop and/or property losses. The design criteria set forth to obtain this objective measurement indicated that the instrument would need to 1) record each occurrence to the nearest minute, 2) be able to record at least three separate hailstorms

between servicing, 3) operate without a 110-volt, outside power source, 4) measure the total energy and/or momentum produced by each hailfall, 5) furnish a count of the number of hailstones, and 6) be producible at a cost sufficiently reasonable to allow their widespread installation in large hail study areas. It was also recognized that more sophisticated hail instruments that would collect stones for analysis would be desirable for some field studies of hail, but such instruments would be considerably more expensive.

After the six criteria for the hail gage design were delineated, several potential designs were considered. Ideas on potential instrumentation were sought from several other hail scientists and weather instrument experts. The power and cost limitations set forth in our design criteria generally eliminated any recording devices involving the use of cameras or sonic-sensing units.

Two of the instrument plans that evolved were considered worthy of final design and construction. One of these hail gages, which operates like a ballistic pendulum, is in the final stages of construction. Laboratory testing of the completed components indicates that it will function as desired. When completed, it will be field-tested in the summer of 1967 to obtain data which can be compared with damage to nearby crops. Components for the second instrument have been ordered and it should be completed during 1967.

Studies of Surface Hail

The project's fourth phase concerns the collection and analysis of surface hail data. Surface hail data, particularly on the time and place of occurrence, are an essential input for the 1967 and 1968 radar-hail detection study (phase 1). A climatological analysis of these data will furnish knowledge of the mean and extreme values of the size, shape, motion, and duration of hailstorms, as well as information on their areal-temporal relations on given storm days. Such information is also needed to determine properly adequate sizes for hail study areas and the density requirements for recording hail gages.

Data collected from all past field studies of Illinois hailstorms will be a part of the data sample. However, much of the surface hail data to be analyzed to accomplish the above purposes is being and will be collected during 1967 and 1968 in the 18,440-square-mile study area in east central Illinois. The object of our data collection activities is to obtain the maximum possible amount of surface hail data within this area, and to accomplish this goal has required considerable time and effort during the first year of the project.

The major data source that has been developed is a network of volunteer hail observers that became operational on April 1, 1967. A total of 3000 farmers scattered

throughout the study area were asked to serve as observers and 1160 agreed, furnishing a density of one observer per 15 square miles. Their 529 mailed reports in the April-May period have indicated that hail occurred on 27 days. Identical network operations in this same area in past years sampled 19 hail days in 1959, 14 in 1960, 14 in 1961, and 19 days in 1962. Additional valuable data have been collected from these observers through 156 telephone calls to those who did not report hail when others around them reported hail. Data on no-hail occurrences are of equal value in this study.

All the major crop-hail insurance companies in Illinois have been contacted cercerning cooperating with us to secure special hail data in the 18,440-square-mile area, and all have agreed to cooperate. During the 1967 and 1968 crop seasons, their adjustors will interview each person with a hail claim and obtain all available data on time of hail occurrence, hail size, other hailfall characteristics, and the amount of crop loss.

Within the study area, the State Water Survey operates two dense raingage networks, one with 49 recording gages in 400 square miles and the other with 16 recording gages in a 300-square-mile area. All the gages have been modified to register the time of hail occurrence (if it produces a signature on the rainfall trace), and at each gage site in the 49-gage network, a foil-covered passive hail indicator has been installed. The raingage-hail pad data is proving

quite useful in developing detailed maps of surface hail patterns and their related rainfall patterns.

Six "stool-type" passive hail indicators have been developed and installed to form a 200-foot by 1100-foot rectangular micro-network in a nearby rural area. The polystyrene stools are wrapped in aluminum foil and allow estimations of hailfall energies, the number and size of stones, the angle of fall, and the direction of fall. These data will be used to study short-distance variability of the above hailfall parameters.

A hail adjustor will work for the project in the 1967 and 1968 crop seasons, and will make detailed field studies of hailstorms, paying particular attention to those within the 400-square-mile raingage-hail pad network. He will also evaluate the degree of crop losses adjacent to each hail pad and the experimental hail gages. A final source of data being employed are the hail reports of U. S. Weather Bureau cooperative observers in the study area.

Personnel

The personnel who are working, either full-time or part-time, on the project are listed below. The names and working titles are sorted according to the phase they are assigned to.

| | |
|---|---|
| Project Supervisor | Glenn E. Stout[1] |
| Principal Investigator | Stanley A. Changnon, Jr.[1] |

Phase 1

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|---|---|
| Radar Supervisor | Donald W. Staggs |
| Radar Meteorologist | Ronald E. Rinehart |
| Radar Operator-Meteorologist | Neil G. Towery |
| Radar Operator | Eberhard Brieschke |
| Radar Maintenance | Joseph Coons |
| Radar Analyst | Susan M. Ting |

Phase 2

| | |
|---|---|
| Climatologist | Dr. Paul T. Schickedanz |
| Analyst | Pamela Collins[1,2] |
| Analyst | Robert Kuchnaw[1,2] |

Phase 3

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|---|---|
| Design Consultant | Professor John E. Pearson[1] |
| Design Engineer | Dr. Eugene A. Mueller[1] |
| Shop Technician | Ronald K. Tibbetts[1] |

Phase 4

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|---|---|
| Meteorologist | Harold Danford |
| Analyst | Edna Anderson |
| Analyst | Karen Wilde[1,2] |
| Hail Adjustor | John Hornaday (summer only)[3] |

1 = Part-time
2 = Student
3 = High school teacher