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Contract Report No. 158

A PRELIMINARY REPORT

ON

UNIQUE HAIL AND TORNADIC STORM OBSERVATIONS

IN

CENTRAL ILLINOIS AND EASTERN INDIANA

ON

3 APRIL 1974

Prepared by the Senior Staff of the Illinois Program

to

DESIGN AN EXPERIMENT TO SUPPRESS HAIL

Grant GI-37859
Weather Modification Program
The Division of Environmental Systems and Resources
Research Applied to National Needs
National Science Foundation

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8 May 1974

INTRODUCTION

As part of a 1973-75 program to Design an Experiment to Suppress Hail (DESH) in Illinois, the Atmospheric Sciences Section of the Illinois State Water Survey has been conducting an intensive field observational project on hailstorms and severe convective weather in Illinois. This project has utilized a very sophisticated radar system, as depicted in Fig. 1, and extensive numbers of various ground-based observing facilities in central Illinois to document the life cycle of storms. This program is supported partly by the Weather Modification Program of RANN (Research Applied to National Needs) Division of the National Science Foundation and partly by the State of Illinois.

The operations for the field project involve, during precipitation periods, continuous vigilance on the part of all project professional and technical personnel. Whenever storms are expected in the vicinity of the ground observing network in central Illinois, the radar is put in operation. After passage of the storms, our teams go out to service the hundreds of observing sites in the networks and to bring back the data. If warranted, other teams go out to perform detailed field surveys of more unusual storms. Between storm events, the weather watch and system maintenance go on continuously, as data flow in from observer-correspondents.

On 3 April 1974 a catastrophic wave of severe weather swept through some ten states in and east of the Mississippi River Valley. At least three major squall-line systems spawned nearly a hundred tornadoes, causing over 300 deaths and thousands of injuries.

The hailstorm project operational effort was in full "go" position during 3 April and all of its operational facilities were brought into play and experienced significant events of considerable research potential. One of the day's 3 major squall systems actually developed in our area on the morning of 3 April. Another was born in western Illinois and spent many hours of its life within range of the radar system which is located at our field laboratory at the University of Illinois Airport.

Due to the exceptional local, state, and national interest which has been expressed about the observations made as part of DESH, and because of our own desire to inform potential users of the project results and storm information, this preliminary summarization of our activities and observations during and following the severe weather wave has been prepared.

This preliminary report is only intended to present a brief description of events in Central Illinois and Eastern Indiana, the area within our radar observing capability, and to describe the subsequent observations and initial results we have obtained during the course of this exceptional wave of severe weather.

THE OBSERVING FACILITIES

The observations which are the subject of this report were derived from several facilities which comprise a large observational system operated as part of DESH. Certain DESH studies relate to the desirability of hail suppression, and include study of public attitudes, potential ecological impacts, and economic aspects. The principal feasibility studies relate to storm modeling, forecasting, cloud and storm sampling, and evaluation.

The primary meteorological facilities of DESH are:

1) Forecasting and analysis facility
   a) Standard operational forecasting equipment and displays
   b) Radiosonde station
2) The CHILL (Chicago-Illinois) dual wavelength radar (Fig. 1) which includes
   a) 3-cm radar, integrated, 1000 gates
   b) 10-cm radar, integrated, 1000 gates
   c) dual wavelength processer for
      i) hail detection
      ii) liquid water content estimation
      iii) 10-cm doppler measurements
3) Field observation facilities (see Figs. 2 and 7)
   a) 700 square mile hailpad and raingage network; 3 mile spacing between sites
   b) 196 square mile dense hailpad network; 1 mile spacing
   c) 5-station meteorological network (temperature, relative humidity, and wind)
   d) 5-county network for hail and severe weather reporting by 348 observers in and around network
   e) 0.3 square mile ultra dense hailpad network; <0.1 mile spacing
   f) field survey teams

DATA SUMMARY

A schematic representation of the major weather features and the data collection activities of 3 April 1974 is shown in Fig. 2. The data

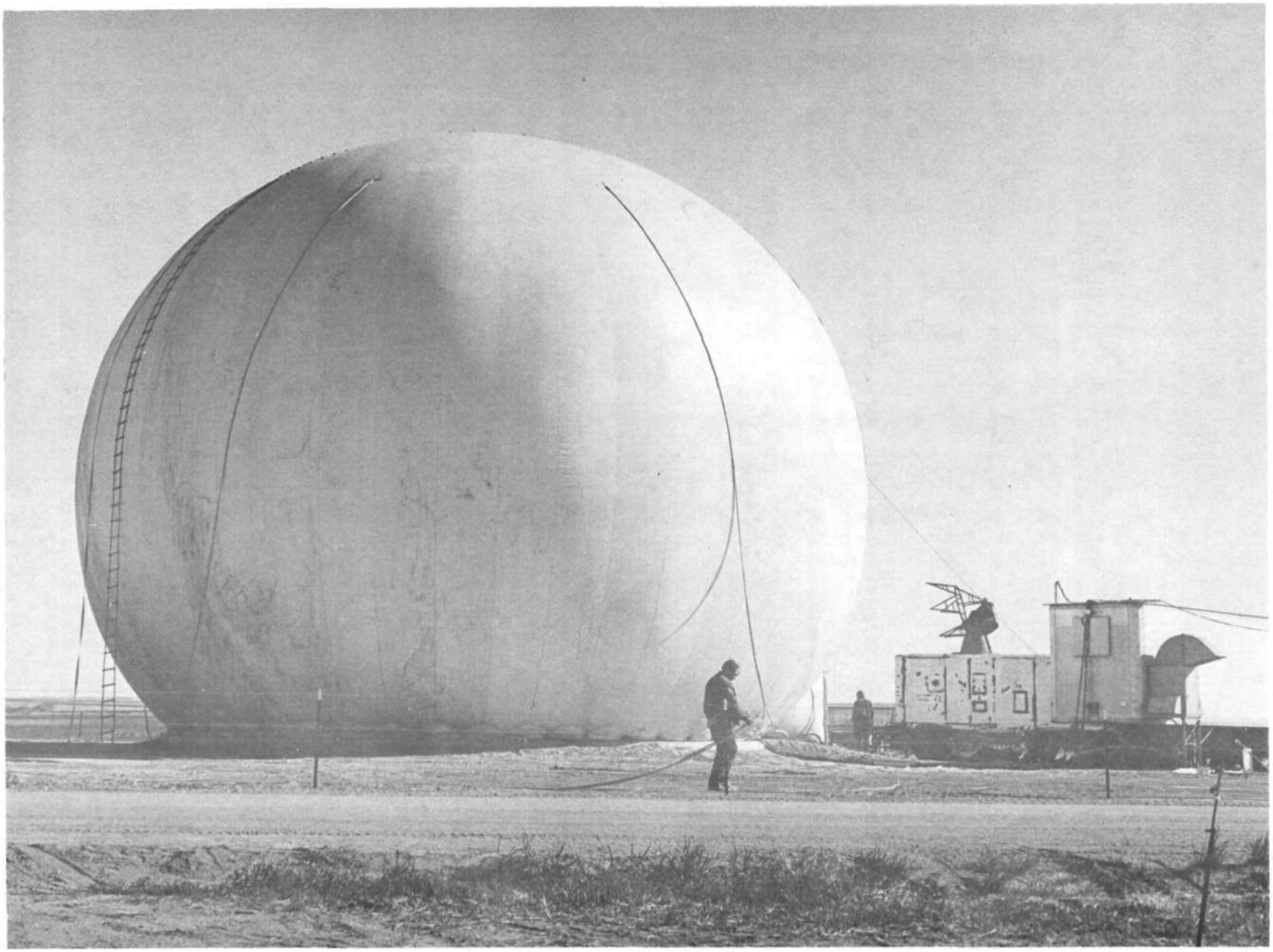


Figure 1. The CHILL radar

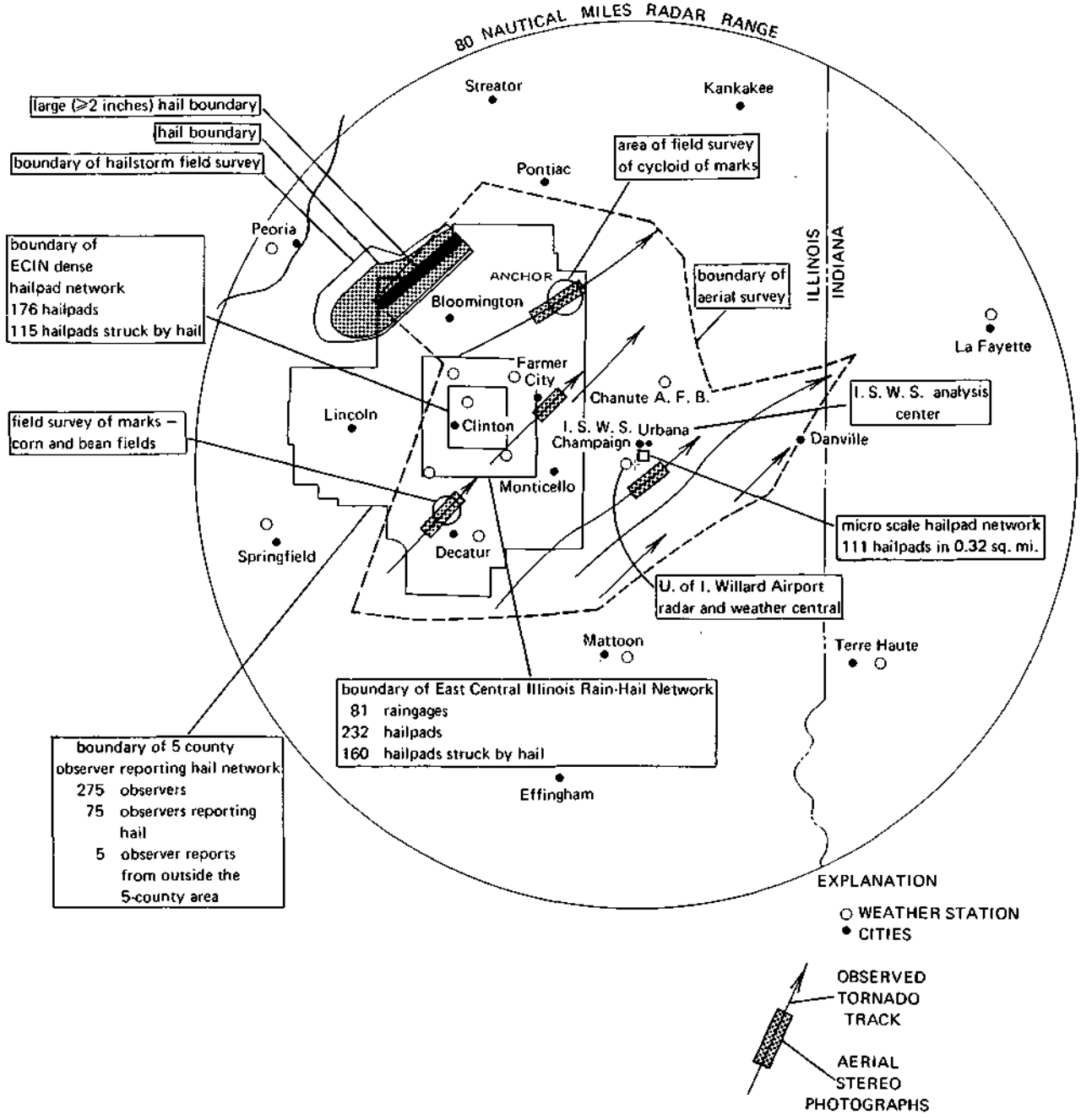


Figure 2. Overall display of major severe weather features and data collection activities

summarized below are not as yet completely inventoried. Nevertheless, the following summary shows the broad dimensions of the data collection.

Radar Data. Over seven hours of continuous recording of dual wavelength radar data (reflectivity, hail signals, and liquid water content in storms). The data are recorded on 15 magnetic tapes and on 35 mm scope photographs. Doppler wind observations are scattered throughout period with several intervals covering known tornadoes. A sampling of the 10-cm radar photographs is shown in Fig. 4.

Aerial Surveys. Nine flight hours of surveying on two days (4 and 5 April), and over 700 miles of flight. Results summarized in report based on our observer's log show 107 frames of 35 mm color film, all catalogued and locations plotted. Following the aerial survey flights, instructions were given to a commercial aerial photography firm to perform high quality stereo photographic missions over specified areas, as shown on the map of Fig. 2.

Field Survey Data. This was accomplished on 6 April, and we have stereo-pair photographs covering 75 miles of tornado tracks. Photographs are in a 9 x 9 inch format and were taken from 6000 feet. An example of these aerial photographs is shown in Fig. 5.

Ground Survey. Ground survey of area of severe hailstorms (3-inch diameter hailstones) and photographs of damage to roofs and buildings; a large collection of selected hailstones in storage. Field surveys of tornado markings also were carried out in two areas: near Anchor and near Decatur; numerous 35 mm color photographs were taken of debris in fields. Reports based on observer's logs are on file. Some of the hailstones collected are

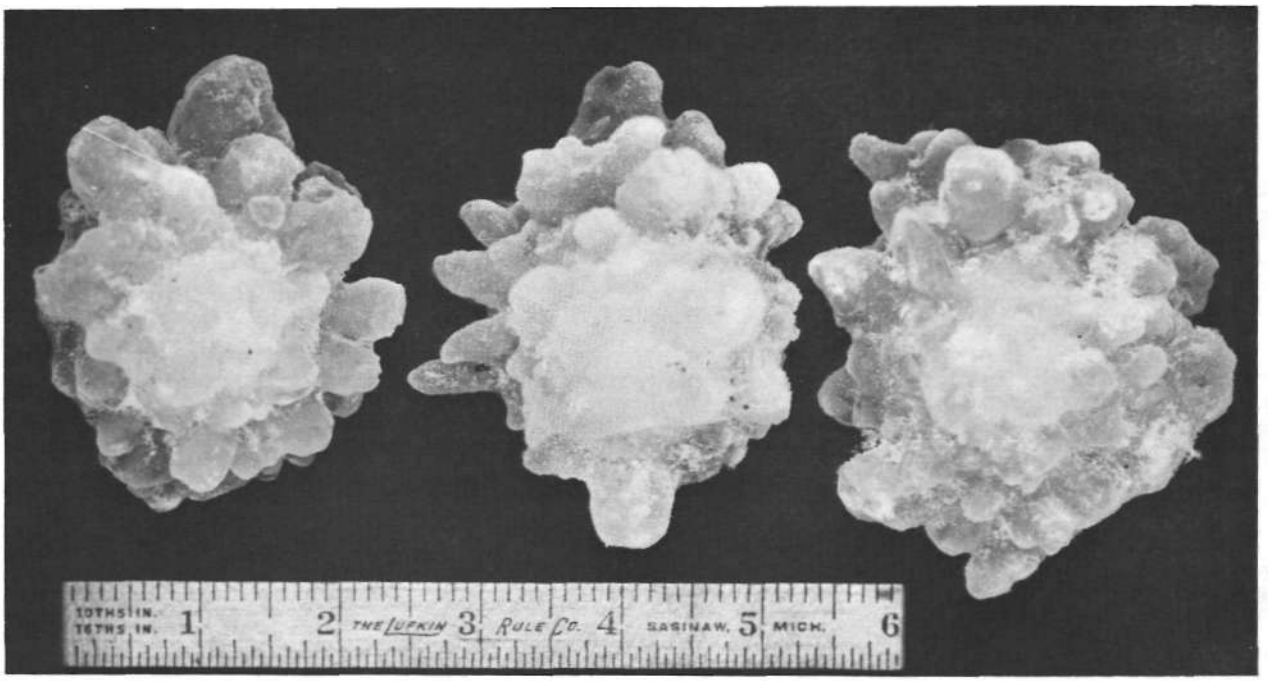


Figure 3. Samples of large hailstones collected near Carlock, Illinois. Scale is in inches.

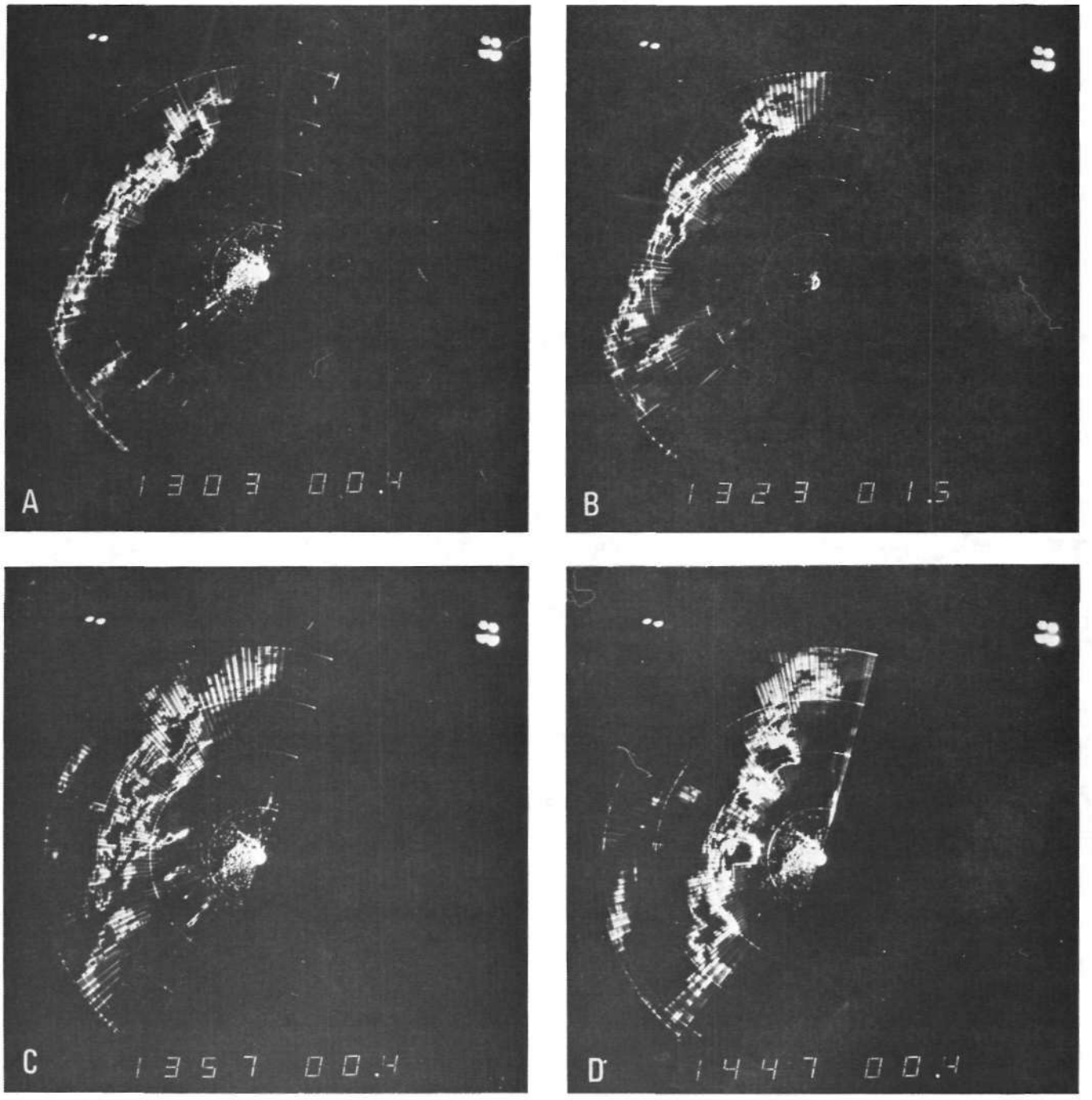


Figure 4A - 4L. A sampling of PPI radar photographs during passage of the severe squall line of 3 April 1974. Range rings are at 20 nm spacing. The time in CDT and the elevation angle in degrees are shown at the bottom on the scope in each frame. In (A) the first major hook echo of the day is to the northwest at about 50 nm. This storm produced 3-inch hail and reports of rotating cloud bases, but no confirmed tornado. At least 3 tornadic echoes are visible in (D). (E) is a higher angle view of (D).

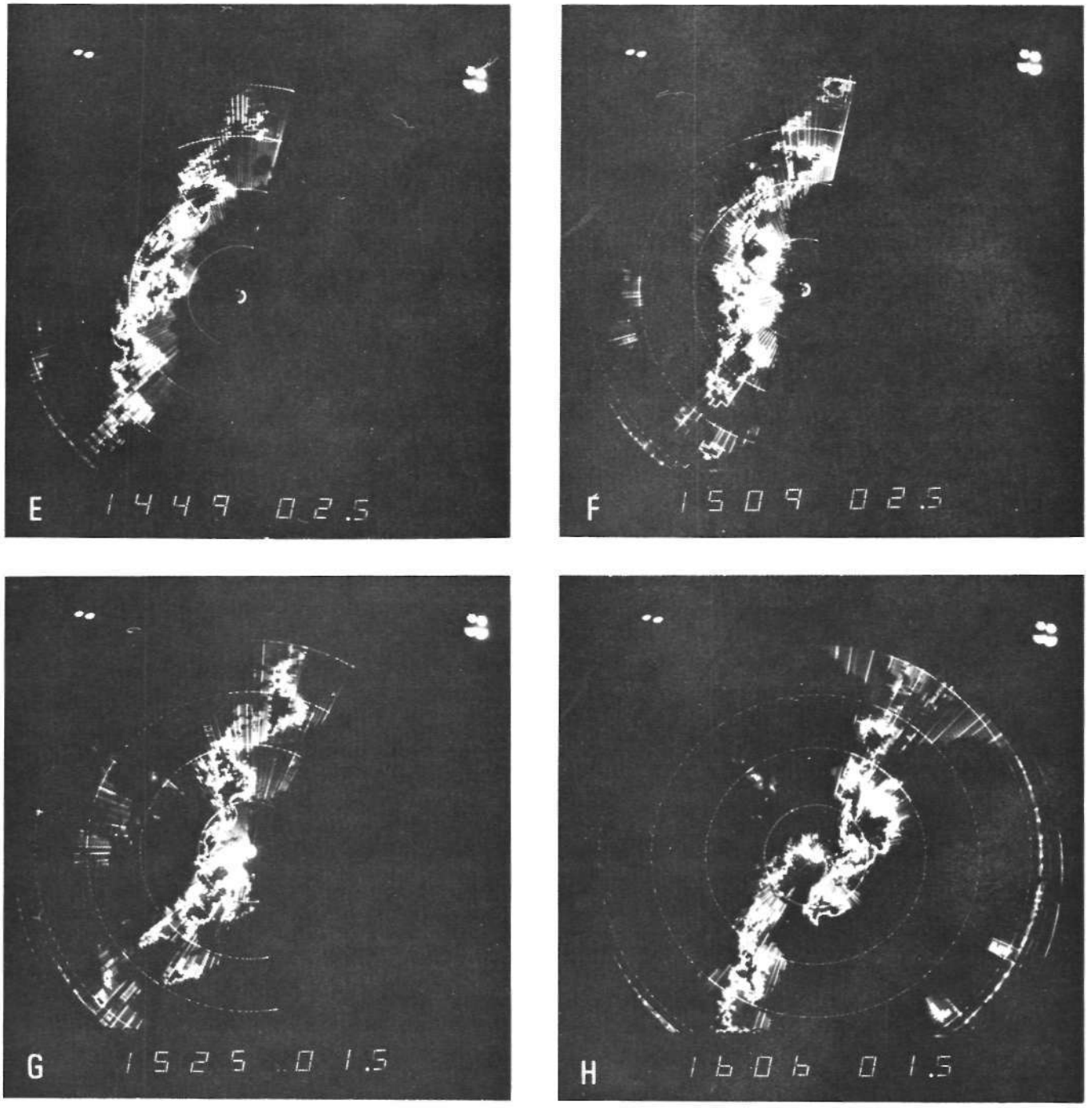


Figure 4A - 4L (Continued)

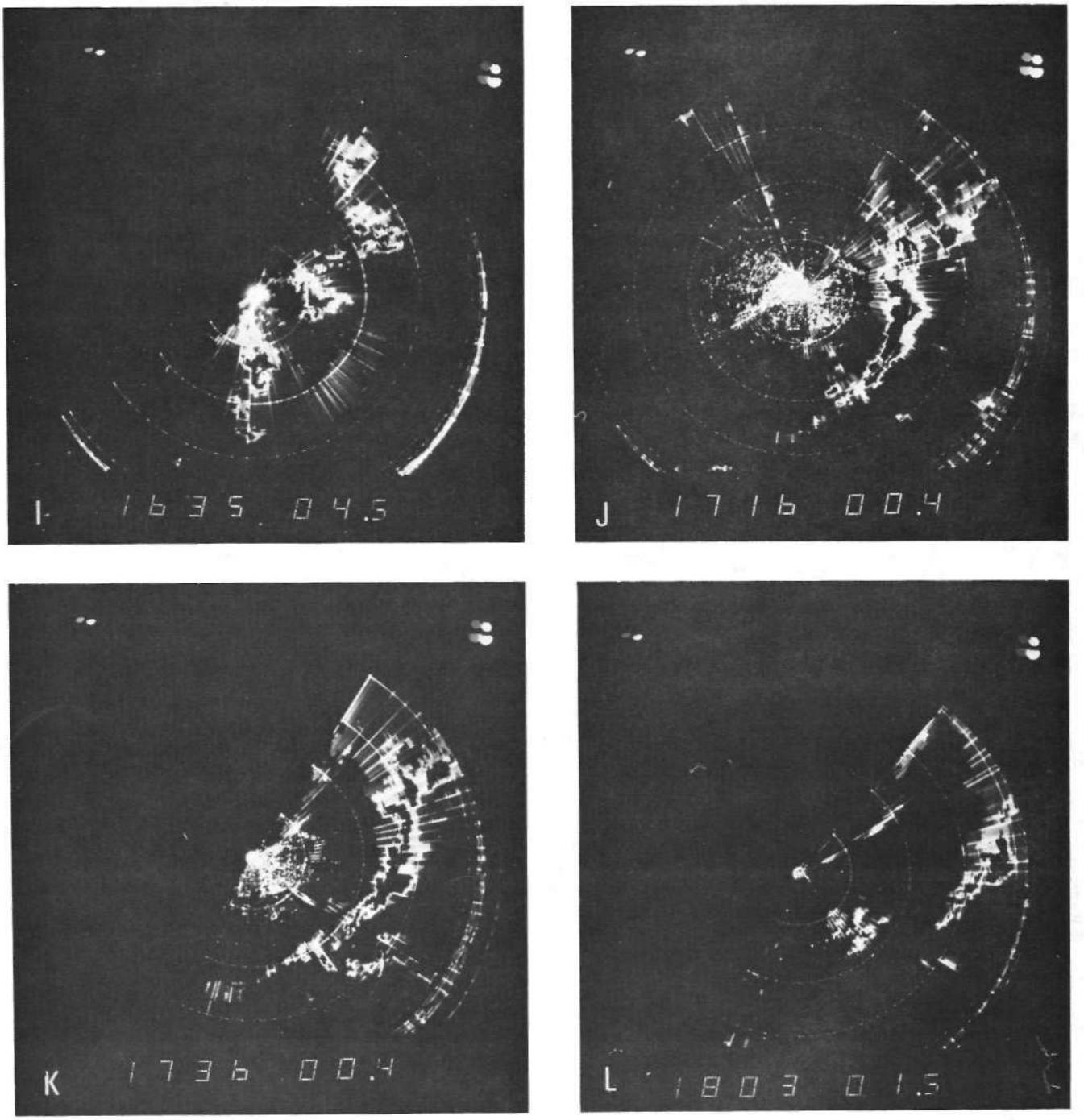


Figure 4A - 4L (Concluded)

Figure 5. Aerial photograph of cycloidal marks in fields near Anchor, Illinois

shown in Fig. 3. Figure 6 shows a view of the ground investigation of cycloidal marks near Anchor.

Weather Forecasting and Analysis. Complete data from two teletype circuits and facsimile are on file; some teletype data are being placed on punched cards for intensive synoptic studies. Two radiosondes were released from the Airport field site (Fig. 2); one ahead of and one just behind the squall line.

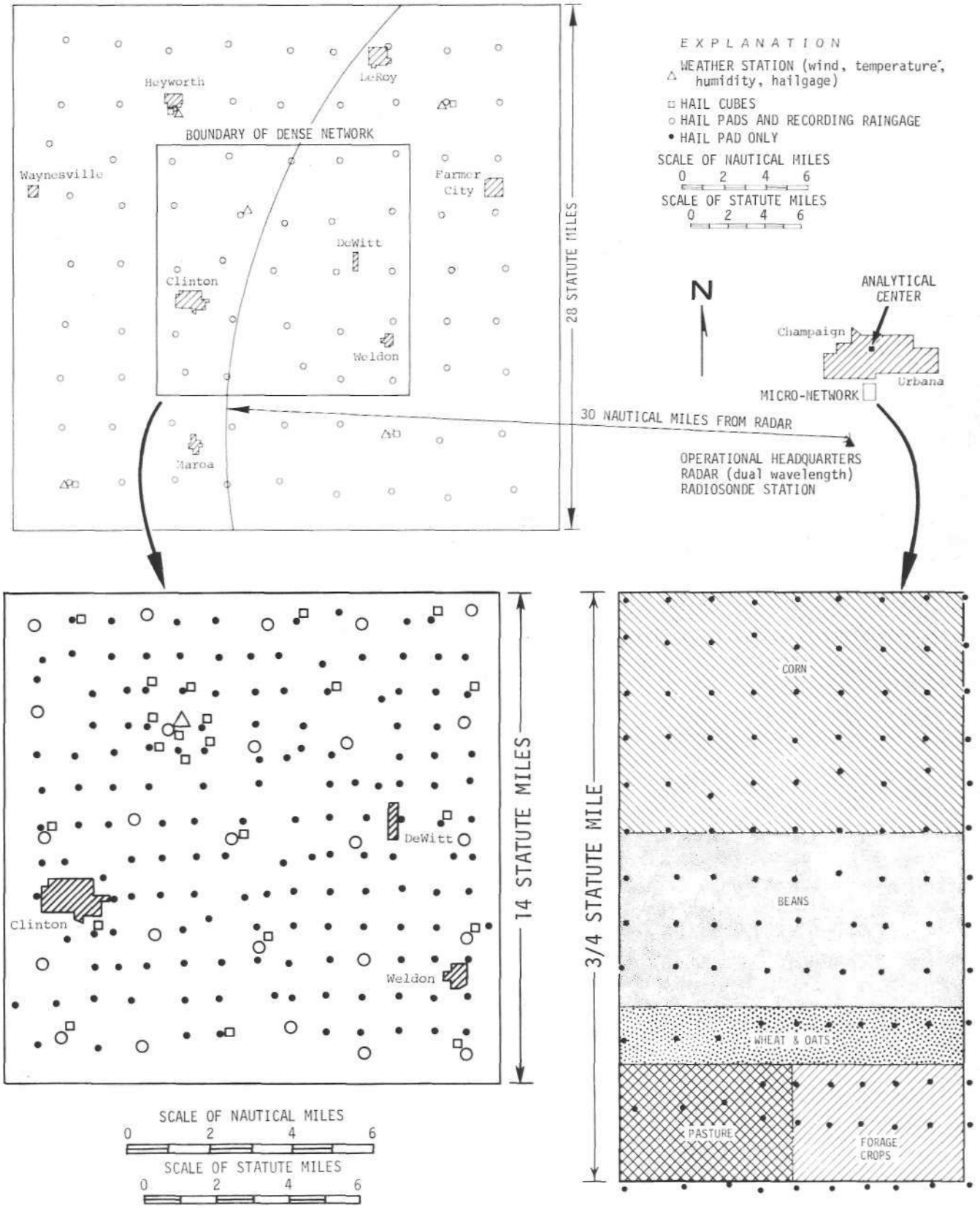
Surface Network Data. Hail fell on all surface networks during the passage of this squall system, and one known tornado passed through the large network. A map of the rain and hail patterns, the tornado track and rain initiation isochrones for the network area is shown in Fig. 7.

RESEARCH EXPLOITATION OF THE DATA

On this and several other days in the Spring of 1974 we have observed and recorded numerous "hook" echoes. Some of these were associated with reported tornadoes and some were not. These data will allow us to make meaningful studies of the spatial relationships between echo features and tornadoes, the vertical structure of tornadic echoes, and perhaps determine the characteristics which distinguish the tornadic from the non-tornadic "hook" echo. For most of the tornadoes we have recorded the entire radar-detectable life in great detail, providing a unique research opportunity.

At the same time, playback of the echo characteristics will allow examination of the mechanics of formulating and disseminating forecasts and warnings to the general public and to operational components of a hypothetical weather modification experiment.

Figure 6. Researchers examining a loop in a cycloidal mark near Anchor, Illinois



DENSE NETWORK

MICRO-NETWORK

Figure 7. The Illinois State Water Survey surface hail observing networks

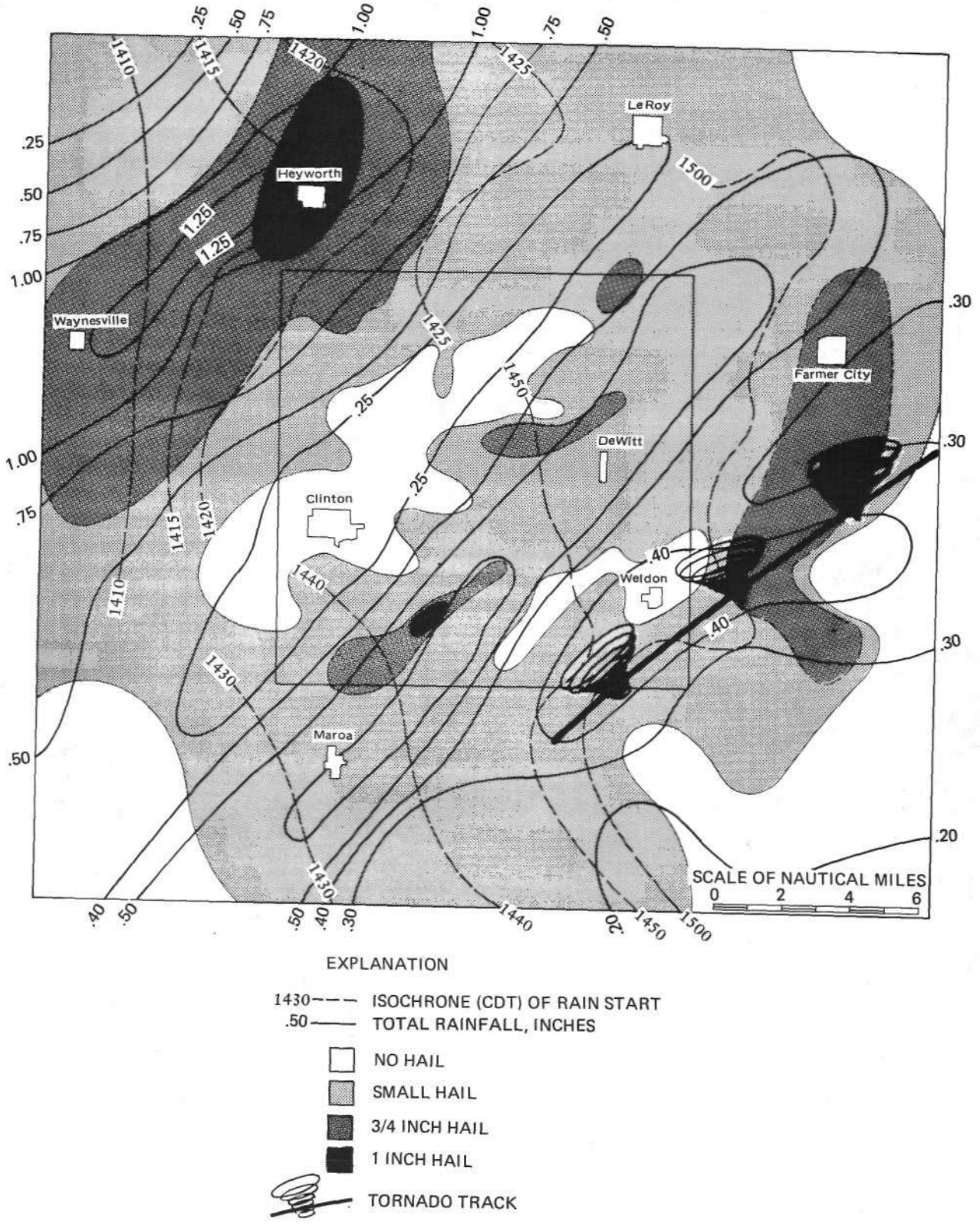


Figure 8. Rain and hail observed on the East Central Illinois Network, 3 April 1974

In pursuit of our DESH program goals, we have been developing a modern, computerized capability for performing synoptic and meso-synoptic meteorological studies, and these will be pursued vigorously. The photographic data on the cycloidal marks will be investigated to determine possible mechanisms for their origin.

The acquisition of doppler wind data on several tornadic storms at nearly optimum range is a long-awaited opportunity. Only a careful sampling of this data will reveal the limits to our analysis potential.

The hail data and relevant radar data will be studied extensively as part of our DESH commitments.

Finally, it is our intention to prepare an exhaustive report on this tornado-hail situation. The report will address two general areas. First will be the various meteorological interpretations, and second the forecast-warning implications for Illinois. These tornadoes are representative of a unique class of the most damaging type in the Midwest. If better means for their detection and prediction of place of occurrence, on scales of 10 to 60 minutes in advance, can be derived, it would represent a major step forward.

ACKNOWLEDGMENTS

We express our appreciation to the volunteer members of the 5-county reporting network who experienced these storms and gave us extensive reports. We also thank the many people who consented to being interviewed and allowed us to examine their property during the field investigations.