

Circular 64

STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*



*Illinois Cooperative Project
in Climatology*

*Third Progress Report
July 1, 1956 Through August 31, 1957*

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*A Cooperative Project of the
State Water Survey Division and the
United States Weather Bureau*

STATE WATER SURVEY DIVISION
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During the present report period, the project was under the direction of William C. Ackermann, Chief of the Illinois State Water Survey, and the general supervision of Glenn E. Stout, Head of the Meteorology Section. Ann Wallace served as the keypunch operator and also assisted in the card checking and editing phases. Marvin Clevenger handled machine operations for card analysis. The author of this report supervised the project and served as the editor.

The State Climatologist for Illinois during this report period was Lothar A. Joos, and in this capacity, he assisted as the immediate representative for the United States Weather Bureau. The cooperation of Leslie Smith and his staff at the National Weather Records Center, Asheville, North Carolina, is also greatly appreciated.

Personnel of the University of Illinois Statistical Service Unit continued to assist the program

by making available machine facilities and providing technical advice in use of machines and analysis of data. George R. Beam, Director, and Bud Joseph Meador of the Research Section were primarily responsible for this assistance and guidance.

INTRODUCTION

The present report discusses the progress of the Illinois Cooperative Project in Climatology for the period from July 1, 1956 through August 31, 1957. The 33-month project conducted by the Illinois State Water Survey in cooperation with the United States Weather Bureau began December 1, 1954, and the punching of Illinois data terminated on July 31, 1957. This third report describes the card punching completed during this report period and during the entire project. In addition the research which has been accomplished utilizing the punched cards during this report period is also discussed.

TABLE 1
ILLINOIS COOPERATIVE SUBSTATIONS ENTERED ON No. 1009 CARDS
July 1, 1956 to August 31, 1957

Station	Code Number	Length of Record Punched*
Aledo	110072	1/1/01 - 12/31/48
Charleston	111436	1/1/01 - 12/31/48
Decatur	112193	1/1/01 - 12/31/48
Dixon	112348	1/1/01 - 12/31/48
Effingham ⁽¹⁾	112687	1/1/01 - 6/30/03 6/1/11 - 12/31/48
Fairfield ⁽²⁾	112931	1/1/01 - 12/31/48
Flora	113109	1/1/01 - 12/31/48
Freeport ⁽³⁾	113257	1/1/09 - 12/31/48
Galva	113335	1/1/01 - 12/31/48
Hillsboro	114108	1/1/01 - 12/31/48
Jacksonville ⁽⁴⁾	114442	1/1/01 - 12/31/48
Joliet**	114535	1/1/01 - 12/31/48
LaHarpe	114823	1/1/01 - 12/31/48
Lincoln	115079	2/1/06 - 12/31/48
Marengo ⁽⁵⁾	115326	1/1/01 - 9/30/17 6/1/18 - 12/31/48
Mascoutah**	115400	1/1/01 - 12/31/48
Morrison	115833	7/1/01 - 12/31/48
Morrisonville	115846	1/1/01 - 12/31/48
Pana	116579	1/1/01 - 12/31/48
Pontiac	116910	1/1/03 - 12/31/48
Quincy ⁽⁶⁾	117067	1/1/01 - 12/31/48
Roberts**	117336	1/1/12 - 12/31/48
Sycamore	118452	1/1/01 - 12/31/48
Waukegan**	119029	1/1/23 - 12/31/48

* Temperature and precipitation unless indicated otherwise.

** Only precipitation and days with data punched.

- (1) Montrose records used June 1911 through March 1918.
- (2) Cisne records used January 1901 through December 1907.
- (3) Dakota records used January 1909 through March 1916.
- (4) Alexander records used January 1901 through April 1927.
- (5) Riley records used January 1901 through September 1917.
- (6) Coatsburg records used January 1901 through December 1911.

STATIONS AND CARD PUNCHING

Illinois Stations

Since June 30, 1956, a total of 433,160 daily summary cards has been punched. The cards include data from two first-order stations and from 24 cooperative substations. Each of these stations had approximately 48 years of record (1901-1948) entered on cards. A listing of the stations and years for which records were entered on cards are given in Tables 1 and 2.

It was decided to estimate the missing precipitation data, and a procedure was devised (Appendix C) based on U. S. Weather Bureau methods. The total days missing per year and total days of missing precipitation are indicated on the final 101 printout for each station, and the number to be estimated was determined from these printouts. A list of the actual dates was then prepared using the original records. The estimation of the values for 9000 missing days was completed by three analysts during this report period. New cards with estimated precipitation amounts were

TABLE 2
FIRST-ORDER STATIONS ENTERED ON NO. 3 CARDS
July 1, 1956 to August 31, 1957

<u>Station</u>	<u>Code Number</u>	<u>Length of Record</u>
Davenport-Moline ⁽¹⁾	14932- 14923	1/1/01 - 12/31/48
Peoria	14842	1/1/05 - 12/31/48

(1) Davenport records from 1/1/01 to 5/23/43 and Moline records from 5/24/43 to 12/31/48.

During the past 33 months all stations in Illinois having approximately 50 years of continuous records of temperature and precipitation have been placed on IBM cards. In addition, other stations with shorter lengths of record or with only precipitation data have been punched to give a more representative distribution of stations throughout Illinois. Stations with daily summary cards provide a spacing of approximately one station per 930 square miles.

At the conclusion of the project, records of 61 stations in or near Illinois as shown in Figure 1 were available on punch cards. The names of the stations, code numbers, and length of records punched, other than those listed in Tables 1 and 2 of this report, are given in previous reports. ^(1,2) Of these 61 stations in Figure 1, two were obtained from Missouri, ^(1,2) and the remaining 59 were punched under the Illinois Cooperative Project.

Card Data

The editing and punching of data for the substations and first-order stations have continued in the same manner as described in the First Progress Report. The type of data entered on the No. 3 cards for Davenport-Moline and Peoria is given in the Appendix A and B.

Since the Illinois State Water Survey has particular interest in precipitation data and related studies, it was desirable to have card data of continuous, unbroken precipitation records. Unfortunately, in the 55 cooperative substation records, there were 10,854 days of missing precipitation and/or completely missing data for the 1901-1955 period.

inserted in the original card decks where records were completely missing. To replace those with only precipitation data missing, new cards were inserted with the temperature data from the old cards entered. All cards with estimated precipitation values have a Y-overpunch in column 26. The cards reproduced for the U. S. Weather Bureau do not have these estimated data entered.

Card Supplies

During the 14-month period covered by this report, a total of 399,555 of the No. 1009 cards and a total of 33,605 of the No. 3 cards were punched. Duplicate cards for the 1901-1948 period were also produced for the U. S. Weather Bureau for all Illinois stations not listed, as being duplicated, in the Second Progress Report. This totaled 48 cooperative substations and two first-order stations which were duplicated during this report period. In addition 2444 monthly summary cards for four stations were duplicated.

The status of the Illinois project with regard to the number of cards received, punched, and duplicated during this report period is shown in Table 3. The stations and years for which punch cards were obtained from the U. S. Weather Bureau are shown in Table 4.

Table 5 gives the final count of cards obtained or punched under the Illinois Cooperative Project. The unaccounted-for cards in Table 5 are attributed to wastage from punching errors. The supply of unpunched cards is being kept for future use, including the possibility of duplicating cards for the exchange of data with states bordering Illinois.

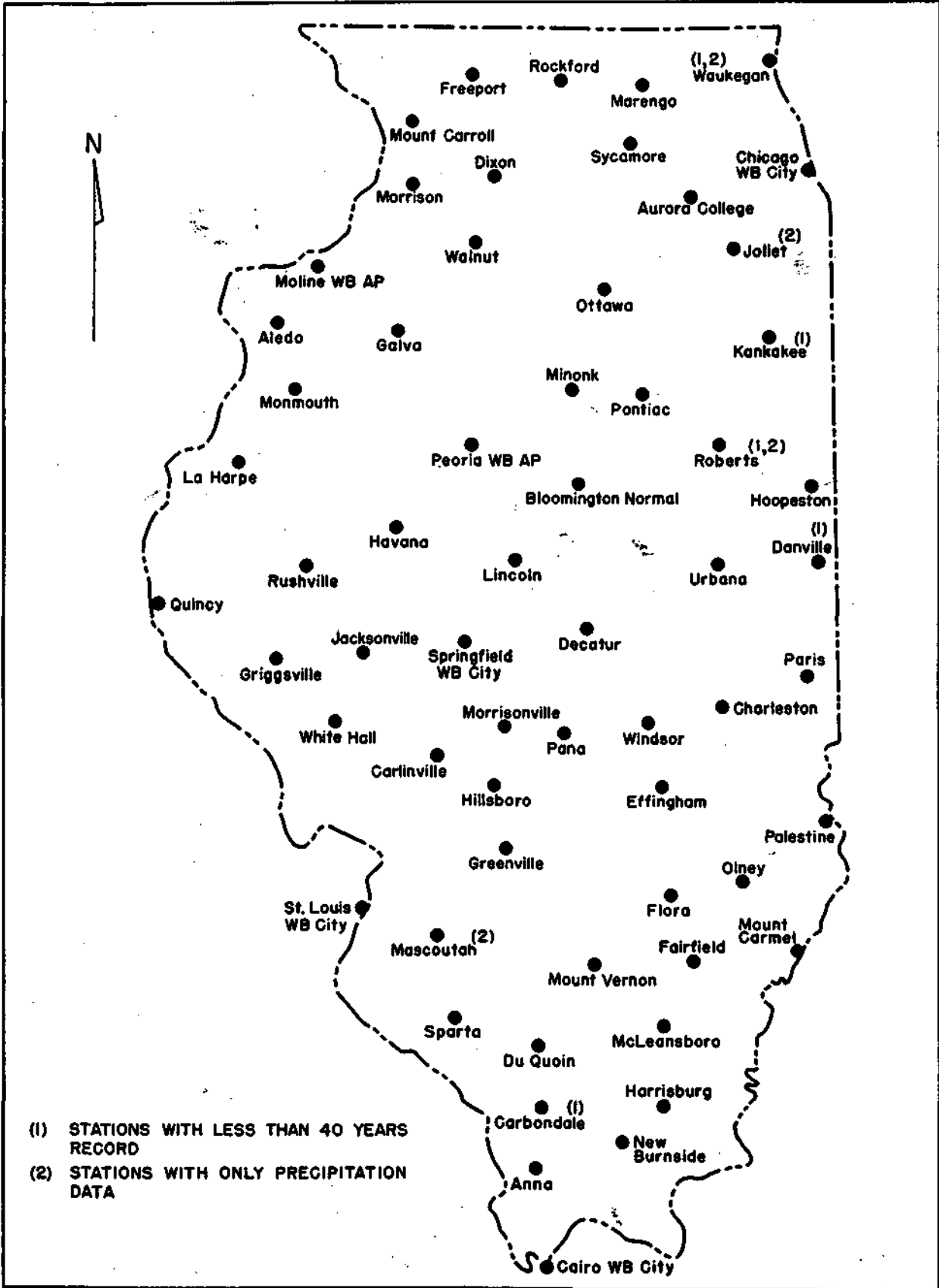


FIGURE 1 ILLINOIS STATIONS WITH PUNCH CARD DATA STATION RECORDS DURING THE 1901-1955 PERIOD

For all 61 stations, punch card records are now complete for the period from 1901 (or as soon after 1901 as the record begins) through 1955.

Cards were requested and received from the U.S. Weather Bureau for all stations for the period 1949 through 1955.

TABLE 3
CARD SUPPLY AND EXCHANGE LISTING

July 1, 1956 to August 31, 1957

Card Type	Number Received ⁽¹⁾		Number Punched	
	Punched ⁽²⁾	Unpunched	Original	Duplicates ⁽¹⁾
No. 1009, IBM 782918	85,432	1,190,000	399,555	812,311
No. 3, IBM 762656	2,925	50,000	33,605	33,605
No. 1, IBM 770759	254,112 ⁽³⁾	none	none	none
No. 5, IBM 802378	none	none	none	none
Monthly Summary, IBM 796158	none	none	none	2,444
TOTALS	342,469	1,240,000	433,160	848,360

(1) Received or sent from Natl. Weather Records Center, Asheville, N. C.

(2) See Table 4

(3) Obtained for use in research projects

TABLE 4
STATION CARDS RECEIVED FROM U. S. WEATHER BUREAU

July 1, 1956 to August 31, 1957

Cards	Stations
No. 1009 (1/55-12/55)	Anna, Aurora, Bloomington, Carbondale Carlville, Danville, DuQuoin Greenville, Griggsville, Havana Kankakee, McLeansboro, Mt. Carroll, New Burnside, Olney, Ottawa, Palestine, Paris, Rushville, Sparta, Walnut, White Hall, and Windsor
No. 1009 (1/49-12/55)	Aledo, Charleston, Decatur, Dixon, Fairfield, Flora, Freeport, Galva, Hillsboro, Hoopston, Jacksonville, Joliet, LaHarpe, Lincoln, Marengo, Morrison, Morrisonville, Mt. Carmel, Pana, Pontiac, Quincy, Roberts, Shawneetown, Sycamore and Waukegan
No. 1009 (1/54-12/55)	Harrisburg, Minonk, Moline, Monmouth, Mt. Vernon, Peoria, Rockford, Springfield, and Urbana
No. 3 (1/53-12/55)	Cairo and St. Louis
No. 3 (1/54-12/55)	Chicago
No. 1 Hourly Cards (periods per station)	Rantoul (1/48-12/55) Evansville, Indiana (1/48-12/55) Terre Haute, Indiana (1/48-12/55) Moline (1/54-12/55) Peoria (1/54-12/55) Chicago (7/55-12/55) Springfield (7/55-12/55)

OPERATIONAL METHODS AND PROCEDURES

Procedures

The editing, punching, and card checking operations continued exactly as described in the First and Second Progress Reports. Research utilizing IBM cards increased considerably during this period and is described in a later portion of this report. Card punching activities ended June 30, 1957, and the 024 numerical key punch in use at the Illinois State Water Survey was returned to the International Business Machine Corporation.

Personnel

The editing, project supervision, and card checking required an editor on three-fourths time basis throughout this period. An experienced key-punch operator was employed on a four-fifths time basis until July 1, 1957. A machine operator for all card analysis, including research projects and machine checking of cards, worked on one-half time basis.

earlier portions of this report. These have been machine produced for specific research projects. The type and quantity of such cards produced are discussed in the research portion of this report according to projects.

101-Machine Sorting of Daily Precipitation Amounts

As mentioned in the two previous project reports, cards from each station were sorted by precipitation amounts. From printouts of these sortings, various studies of rainfall frequencies have been completed for 51 stations for the entire length of record at each station. In addition, second sortings were made for eight stations based on the 1906-1955 period. Maps showing maximum daily rainfall expected to recur at intervals of 2, 5, 10, and 25 years which were computed from these printouts were prepared.⁽²⁾

Thunderstorm Climatology of Illinois

This study was completed during this report period and results are presented in an Illinois

TABLE 5
CARD SUPPLY AND EXCHANGE LISTING
December 1, 1954 to August 31, 1957

Card Type	Number Received		Number Punched	Card Supply
	Punched	Unpunched	Originals and Duplicates	Unpunched
No. 1009	152,672	1,940,000	1,853,842	60,000
No. 3	8,039	160,000	137,290	20,000
No. 1	564,112	none	none	none
No. 5	44,000	none	none	none
Monthly Summary	none	16,000	4,888	10,000
Total Cards	768,823	2,116,000	1,996,020	90,000

Card Production Costs

The average cost of punching and checking all cards produced during this period was 0.5 cent. The production cost for the No. 1009 cards averaged 0.45 cent, while the cost for the more detailed No. 3 card was 1.0 cent. For the entire project, the cost of punching and checking the No. 1009 and No. 3 cards, a total of 995,566 cards, was approximately \$6,000. This figure does not include cost of editing and other supervisory activities for the duration of the project. The cards and shipping costs were supplied by the U.S. Weather Bureau.

State Water Survey report.⁽³⁾ Approximately 9800 monthly summary cards were machine produced from No. 1009 cards for the 26 stations used in this study. These monthly summary cards contain information on the total number of thunderstorms; the number of thunderstorms with precipitation greater than 0.09 inch per day; the amount of precipitation on days of thunderstorms and on days following; the total monthly precipitation; and the number of days of hail, high wind, fog, and sleet with and without simultaneous daily thunderstorm occurrences.

Cloud Census Project

In the Second Progress Report of this project,⁽²⁾ progress and preliminary results of a study concerning the cloud climatology of Illinois were given. During the first 10 months of this

WEATHER CARD RESEARCH PROJECTS

Other cards with weather data have been produced in addition to those accounted for in the

period, the study was completed utilizing hourly cloud data on cards from one Air Force Base and seven first-order stations in and near Illinois for the period of July 1, 1948 to December 31, 1955. These eight stations, except for St. Louis, Missouri, are listed in Table 4 of this report. To accomplish this analysis, 21,920 daily summary cards with cloud amounts and other summary information were machine produced from the No. 1 hourly cards of each station for the 1948-1955 period. An example of results on the annual areal distribution of cumulonimbus in Illinois is shown in Figure 2. The final results of this study are presented in an Illinois State Water Survey report.⁽⁴⁾

Atmospheric Moisture Flow

As mentioned in a previous project report,⁽²⁾ a study of the atmospheric moisture flow over Illinois and its relation to surface precipitation is in progress, utilizing data from No. 5 cards from four stations. The basic calculations are being done by the University of Illinois digital computer, the ILLIAC, which is provided upper air data by tapes prepared by machine transfer of the No. 5 card data. Considerable effort was required to prepare the computation program for the ILLIAC. The printout of the computer calculations lists two daily computations of precipitable

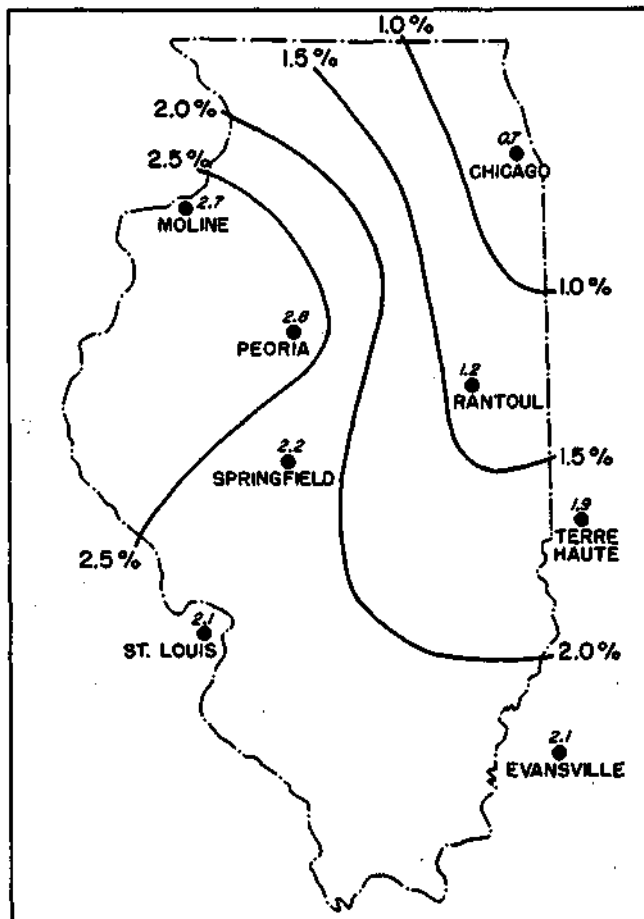


FIGURE 2 AVERAGE ANNUAL OCCURRENCES OF CUMULONIMBUS EXPRESSED AS PERCENT OF TOTAL POSSIBLE OBSERVATIONS

water (in inches) in the layers of 1000 mb to 850 mb, 850 mb to 700 mb, 700 mb to 550 mb, and 550 mb to 400 mb at each station. In addition, calculations of water vapor inflow based on upper wind data are made at each level for each side of a triangle based on Green Bay, Columbia, and Nashville. A further algebraic computation gives the net amount of moisture left within the triangle after the inflow and outflow have been computed. Some of the analysis has been completed, but no results are available as yet.

On the 10,000 cards from each station (March 1953 through December 1955) used in this analysis, there were approximately 1200 missing observations. To accomplish this study, these missing values were estimated and 1200 replacement cards with estimated values were prepared to supplement those with missing data.

Wet-Dry Analysis Program

Machine computations to determine the probability of each date occurring in any length of wet or dry period, based on four amounts of daily rainfall, have been completed for seven cooperative substations using their complete records on No. 1009 cards. The machine procedure used in this analysis was described in a previous report.⁽²⁾ From these data the probabilities of dryness for each date at each level of dryness have been prepared for Aurora, McLeansboro, Mt. Vernon, New Burnside, Rushville, Sparta, and Urbana.

Monthly Precipitation Summary Cards

Monthly precipitation summary cards, in addition to others previously punched,⁽¹⁾ were produced for Monmouth, Mt. Vernon, Rockford, and Urbana. These cards contained precipitation data and related calculations. Machine calculations were made of sliding precipitation totals for periods of 3, 6, 12, 24, 48, and 60 months and the values from these periods were ranked from low to high. The monthly values for each period and its ranking were entered on the individual monthly cards. These cards were punched to enable a preliminary study of techniques for drought analysis, based on statistical evaluation of monthly rainfall data. Some 2544 cards were produced in this analysis.

Weekly Summary Cards

In cooperation with the University of Illinois Committee for Project NC-26 of Weather and Agricultural Production, a total of 29,150 weekly summary cards was produced for 10 Illinois stations, each having approximately 55 years of record. These cards contain total weekly precipitation, maximum temperatures, and minimum temperatures and were made directly by machine summary from daily cards. The instructions for punching were devised by the Committee and will not be included in this report. The weekly numbering system begins with March 1-7 as week number one. The 10 stations for which weekly cards were produced are Aurora, Monmouth, Mt. Carroll, Mt. Vernon, New Burnside, Palestine, Peoria, Sparta, Springfield, and Urbana.

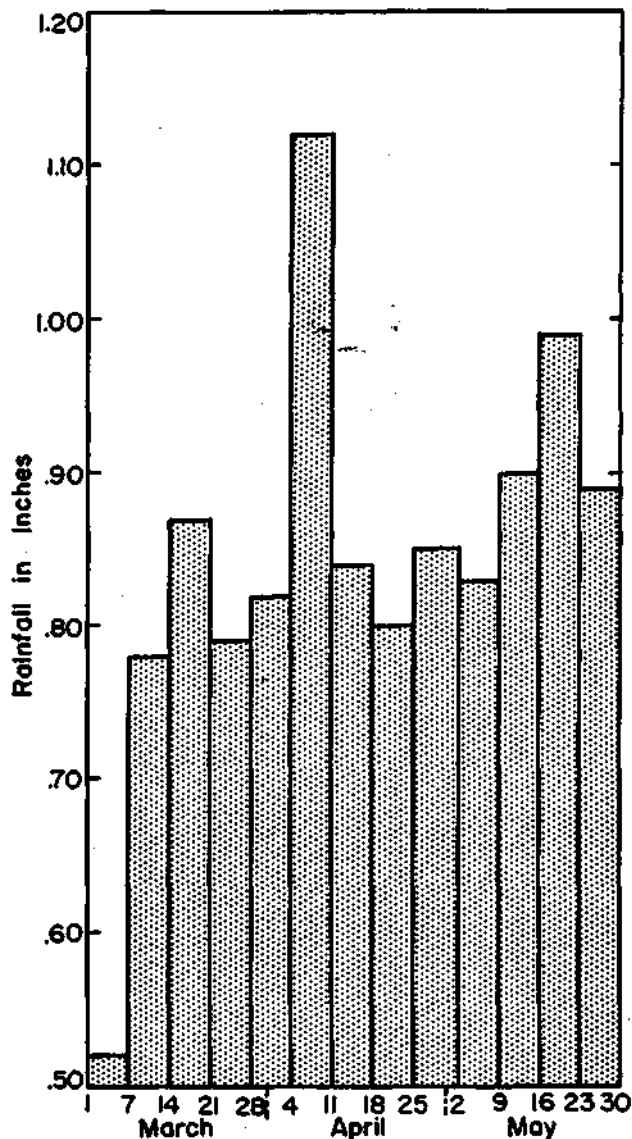


FIGURE 3 AVERAGE WEEKLY PRECIPITATION AMOUNTS AT URBANA, 1903-1955

Duplicates of the cards machine-produced for Project NC-26 were made by the Illinois State Water Survey. From these cards average weekly precipitation, maximum temperature, and minimum temperature were machine calculated for each week at the 10 stations. These data have been used in identifying and analyzing a precipitation singularity in the week of April 5-11 at Urbana, as shown in Figure 3. These data will also be used in a climatological analysis of precipitation and temperatures in Illinois based on weekly periods.

Hail Climatology of Illinois

Utilizing daily summary cards from the first-order stations and cooperative substations, a climatological analysis of hail in Illinois has been initiated. A detailed procedure for evaluating substation records of hail has been developed and

periods of reliable records have been ascertained for 43 substations. An example of the preliminary results is shown in Figure 4.

Precipitation Frequency Studies

A study utilizing IBM cards punched from published climatological data is in progress to determine the recurrence intervals of maximum precipitation for periods of one to ten days throughout Illinois. Another purpose of this research is to investigate methods and techniques for determining reliable frequency relations. The U. S. Weather Bureau⁽⁵⁾ and others have provided data for periods of five minutes to 24 hours, but longer periods of heavy precipitation have not been analyzed in detail for Illinois.

Maximum rainfall data for periods of 1, 2, 3, 5, and 10 days for 39 stations, having 40 years of continuous record during the period 1916-1955, are being analyzed on an annual and seasonal basis. A total of 8000 IBM cards has been punched to record maximum rainfall for each period for each season and year at the 39 stations. The card data are being transferred to tapes to permit analysis by the ILLIAC.

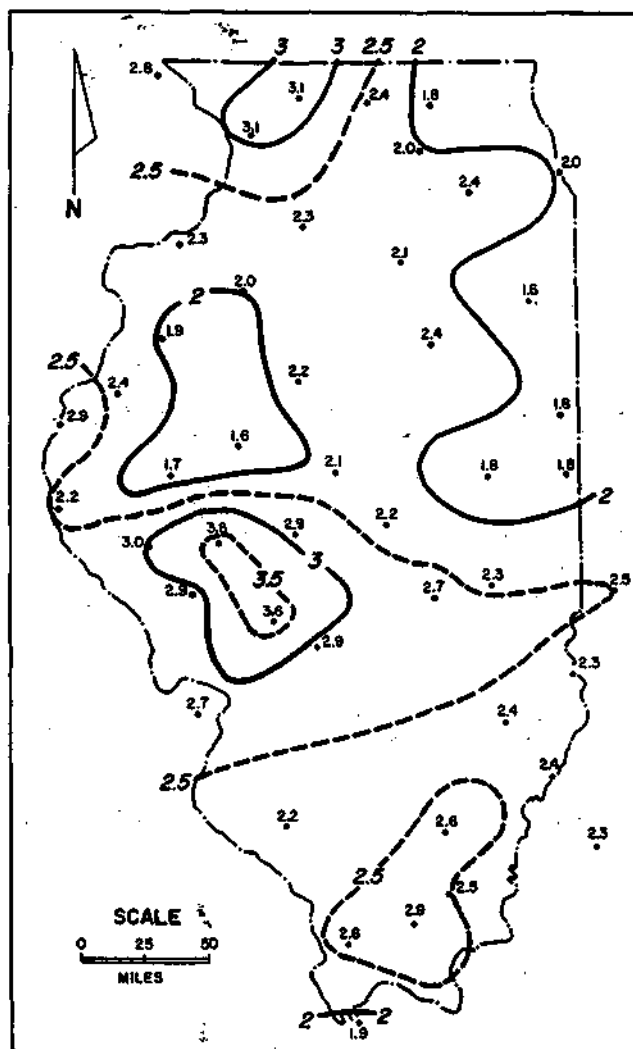


FIGURE 4 AVERAGE ANNUAL HAIL OCCURRENCES IN ILLINOIS. BASED ON RELIABLE RECORDS IN THE 1901-1948 PERIOD

Analysis of One-Minute Rainfall Amounts

Another study utilizing IBM cards for weather research has been in progress, for which cards produced in addition to the Cooperative Project were used. One-minute rainfall values, as determined from recording rain gage charts, are being analyzed to provide a measure of the distribution of rainfall rates within rainshowers and thunderstorms. Such data are pertinent to the development of a better understanding of the physical structure of rainstorms.

For the past five years the Illinois State Water Survey has maintained a dense network of recording rain gages in east central Illinois.⁽⁶⁾ A procedure for machine analysis of the charts from 25 of these rain gages for 25 selected storms during 1953 and 1954 was devised. The cumulative 1-minute amounts indicated on the charts were read on a Benson-Lehner Data Reducer and transferred simultaneously onto IBM cards through a direct connection between the Benson-Lehner

machine and an 024 numerical keypunch machine. For checking purposes, a simultaneous printout of these data were made on an electric IBM typewriter. From these cards, indicating cumulative 1-minute amounts, individual 1-minute amounts were machine calculated on the 407 tabulator; and cards with individual 1-minute amounts were produced. Approximately 9150 cards were produced in this research project.

CONCLUSION

During the past 33 months precipitation and temperature records for 61 stations, each with approximately 50 years of data, have been placed on IBM cards. Although the project is being continued, the transfer of past Illinois weather records to punch cards was discontinued July 31, 1957. Numerous analyses have been performed and the card data are available to staff members of the University of Illinois and state agencies for further studies requiring climatological data.

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APPENDIX

A Data Entries in the Davenport-Moline No. 3 Cards

The daily maximum and minimum temperatures during 1901-1948 were recorded for the period from midnight to midnight. Snowfall was recorded at 8 PM from 1901 through 1908, but beginning in 1909 the daily total was recorded at midnight. Snowdepth was entered as that reported at 7 PM. Rainfall was recorded at 8 PM from 1901 through 1904, and at midnight thereafter.

The AM pressure (columns 28-31) was recorded at 7 AM and the PM pressure (columns 32-35) at 7 PM. The pressure was reported in inches from 1901 through 1943, but beginning in 1944 pressure values were recorded in millibars to a tenth of a millibar.⁽¹⁾ The AM relative humidity (columns 36-38) was recorded at 7 AM from 1901 through 1948. The PM relative humidity (columns 39-40) was recorded at 7 PM from 1901 through 1915; at 1 PM during 1916-1917, and at 12 noon from 1918 through 1948. Beginning June 1, 1940, the pressure and humidity observations were made at the Moline Airport rather than at Davenport.

Days with data were altered in the 1901-1948 cards with drizzle occurrence punched in column 45 and tornado occurrence punched in column 46.

Beginning January 1, 1929, the wind and sunshine records were made at the Moline Airport rather than at Davenport. No wind or sunshine data were available in the 1901-1904 period. Beginning in 1905, the daily prevailing wind direction (columns 64-65), the average daily wind velocity (columns 66-68), the percent of possible sunshine (columns 69-71), and the hours of sunshine (columns 75-77) were available and punched. From 1944 through 1948, the amount of sunshine which was given in hours and minutes was converted to hours and tenths of hours.

B Data Entries in the Peoria No. 3 Cards

The Peoria station was located in the city from January 1, 1905, until officially relocated at the Peoria Airport on May 4, 1943. The daily maximum and minimum temperatures were recorded during the period from midnight to midnight. Snowfall was recorded at 7 PM from 1905 through 1908; but beginning in 1909, the daily total was recorded at midnight. Snowfall values for

February through April, 1943, in the city were missing. Snowfall amounts at the airport were entered in the cards for these three months although the city location was the official station. Snowdepth measurements were made at 7 PM from 1905 through 1948. Rainfall was recorded at midnight from 1905 through 1948.

The AM pressure (column's 28-31) was recorded at 7 AM and the PM pressure (columns 32-35) at 7 PM. All PM pressure readings were missing for 1905 and several that were missing in 1906 were indicated by leaving columns 32-35 blank. The pressure values were recorded in inches from 1905 through February, 1943. Beginning April 1, 1943, all pressure values were recorded in millibars to a tenth of a millibar.⁽¹⁾ The AM relative humidity (columns 36-38) was recorded at 7 AM from 1905 through 1948. The PM relative humidity (columns 39-40) was recorded at 7 PM from 1906 through 1916, then at 2 PM in 1917, and at 12 noon from 1918 through 1948. No PM data were available in 1905 and columns 39-40 were left blank.

All other data for days with events, sunshine, and wind were entered according to instructions for punching given in the First Progress Report.

C Method of Estimating Missing Daily Precipitation Amounts

The method devised to estimate missing daily precipitation at a station was based upon data from four or more surrounding stations in a diamond-shaped pattern or upon data from no less than three surrounding stations in a triangular-shaped pattern. If the three or four surrounding stations had values equal to or less than 0.10 inch, the values were averaged to get the estimate. If any of the surrounding stations had a value equal to or greater than 1.00 inch, an isohyetal map based on four stations was drawn and the estimate based on a value interpolated from the map. If, in the isohyetal method, the pattern from the four stations was still doubtful, all additional stations in the immediate area were plotted. For station values in the range of 0.10 to 1.00 inch, the estimated value was obtained by the 4-station average method if the 4 values had no greater than 0.10 inch difference or if 2 values were high and 2 were low (a 2-2 or 1-2-1 combination). However, if a 1-3 combination of values (one high and three low or one low and three high) existed, the isohyetal method was employed.