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STATE OF ILLINOIS
WILLIAM G. STRATTON, ***Governor***

Second Progress Report
Illinois Cooperative Project in Climatology
1 July 1955 Through 30 June 1956

by
STANLEY A. CHANGNON, JR.

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

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Serving as the State Climatologist for Illinois, during this report period were, successively, Paul Sutton, Robert Lautzenhiser, and Lothar A. Joos; and in this capacity each assisted as immediate representative for the United States Weather Bureau. H. C. McComb, Meteorologist in charge of the Columbia, Missouri, Weather Bureau office, furnished the duplicate cards for the St. Louis records.

Patricia Howe was in charge of machine operation for card analysis and also served occasionally as a keypunch operator. Marvin Clevenger handled machine operations for card analysis on a part-time basis, and Ann Wallace and Robert Ericson served as full-time and part-time keypunch operators, respectively. The author of this report supervised the project and served as the Editor.

Second Progress Report

Illinois Cooperative Project in Climatology

by

Stanley A. Changnon, Jr.

INTRODUCTION

The present report discusses the progress of the Illinois Cooperative Project in Climatology for the period 1 July 1955 through 30 June 1956. This project is being carried on by the Illinois State Water Survey in cooperation with the United States Weather Bureau.

The Illinois State Water Survey has continued the project under the same general plan and procedures as described in the First Progress Report, published in 1955 as State Water Survey Circular 51.

The purposes of the Second Progress Report are to describe the progress in card punching of data from United States Weather Bureau stations, to discuss any deviation from the procedures described in the First Progress Report, and to report on climatological research being done by use of the punched cards. The methods developed for analysis of the machine card data are also described in detail.

STATIONS AND CARD PUNCHING

Illinois Stations

After 19 months of activity on the Illinois Cooperative Project in Climatology, considerable progress has been made in entering long-term weather records on IBM cards. Since the beginning of the project on 12 December 1954 a total of 33 stations has been completed. Since 1 July 1955, the date of the First Progress Report, a total of 24 stations with records approximating 48 years each (1901-1948) has been entered on cards. These include 23 climatological cooperative substations and one first-order station. In addition, the St. Louis, Missouri, duplicate deck for the period of 1908-1952 has been received from the Missouri Cooperative Project. Five studies have been started making use of the cards now available. These studies are described in the Research Projects section of this report.

A total of 406,770 cards has been punched since 1 July 1955, and the total number since inauguration of the project in December 1954 is 564,800 punched

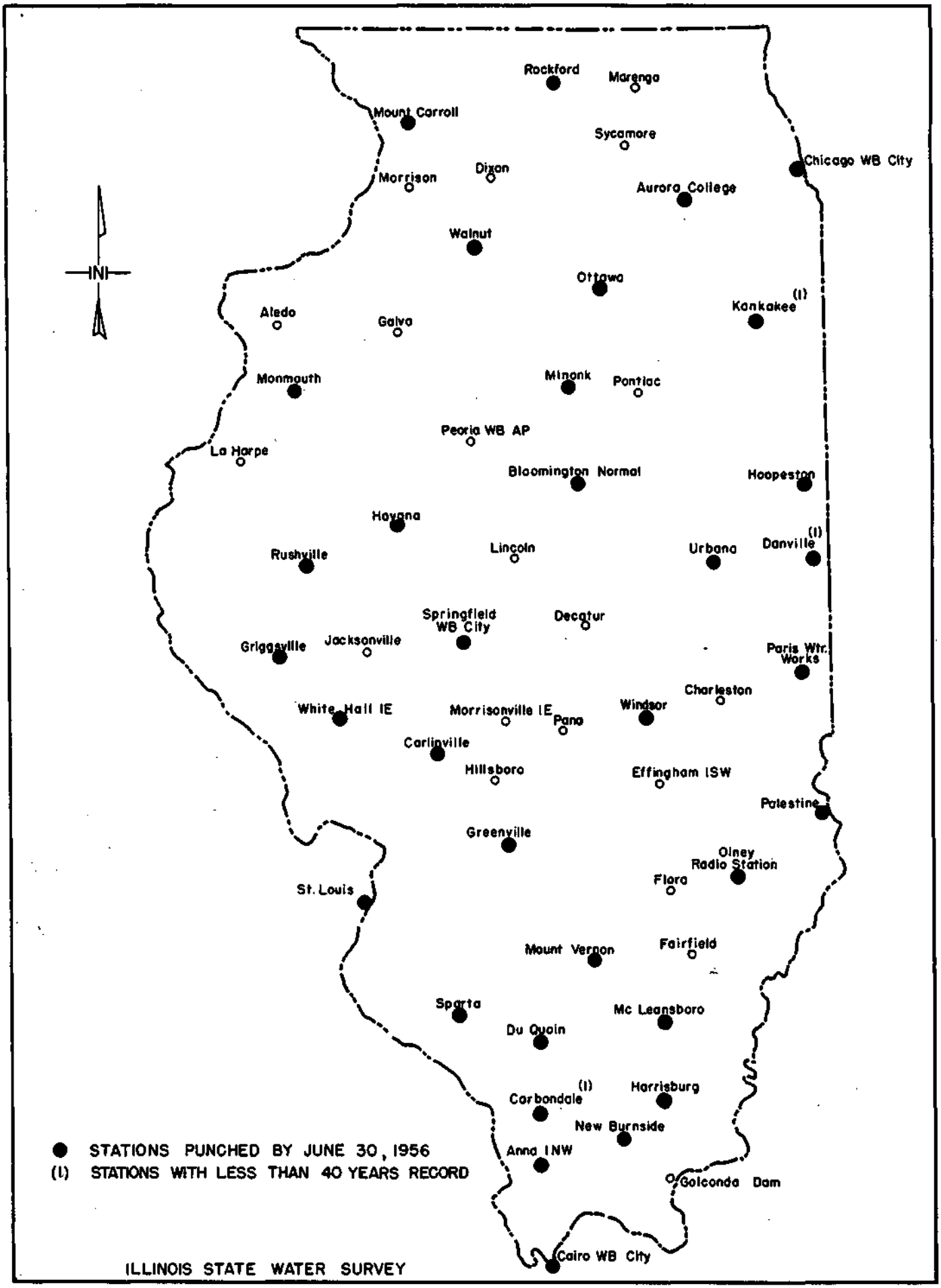

FIG.1 ILLINOIS STATIONS RECORDING 50 OR MORE YEARS OF TEMPERATURE AND PRECIPITATION

cards. The completed stations for this period, their code numbers, and their length of record on cards are listed in Tables I and II. The location of these stations can be found by referring to Figure 1.

TABLE I

ILLINOIS COOPERATIVE SUBSTATIONS ENTERED ON 1009 CARDS
(7/1/55 - 6/30/56)

Station	Code Number	Length of Record Punched (Temperature and Precipitation)
Anna[1]	110187	1/1/01 - 12/31/48
Aurora	110338	1/1/01 - 12/31/48
Bloomington	110766	1/1/01 - 12/31/48
Carbondale	111265	2/1/10 - 12/31/48
Danville	112140	1/1/01 - 12/31/04
[2]		1/1/11 - 12/31/48
DuQuoin	112483	1/1/01 - 12/31/48
Greenville	113693	1/1/01 - 12/31/48
Griggsville	113717	1/1/01 - 12/31/48
Harrisburg[3]	113879	1/1/01 - 12/31/48
Havana	113930	1/1/01 - 12/31/48
Hoopeston	114198	6/1/02 - 12/31/48
Kankakee	114593	1/1/17 - 12/31/48
McLeansboro	115515	1/1/01 - 12/31/48
Mt. Carmel[4]	115893	1/1/02 - 12/31/48
Mt. Carroll[5]	115901	1/1/01 - 12/31/48
Olney	116446	1/1/01 - 12/31/48
Ottawa	116526	1/1/01 - 12/31/48
Paris	116610	1/1/01 - 12/31/48
Rushville	117551	1/1/01 - 12/31/48
Sparta[6]	118147	1/1/01 - 12/31/48
Walnut	118916	1/1/01 - 12/31/48
White Hall[7]	119241	4/7/02 - 12/31/48
Windsor	119354	1/1/04 - 12/31/48

(1) Cobden records used January 1901 through March 1914.
(2) St. John records used January 1901 through October 1908.
(3) Equality records used January 1901 through September 1919.
(4) Friend Grove records used January 1902 through August 1908.
(5) Lanark records used January 1901 through March 1916.
(6) Tilden records used January 1901 through July 1910.
(7) Carrollton records used April 1902 through July 1908.

Selection of stations continued to be made according to the procedures stated in the First Progress Report which were as follows:

1. Records of the stations should begin about 1901 to result in approximately 50 years of card record.

2. Stations must be selected so as to furnish widespread geographical coverage of Illinois.

3. Both temperature and precipitation records must be available at each station.

Data from two stations with considerably less than 48 years of record were punched. These stations were Carbondale and Kankakee. The Kankakee records were chosen as representative in a large area devoid of stations with long-term records. The records at Carbondale were needed for precipitation studies in that part of Southern Illinois.

The first-order stations entered on cards and received from the Missouri Cooperative Project during this report period are listed in Table II.

TABLE II

ILLINOIS FIRST-ORDER STATIONS ON NO. 3 CARDS

Station	Code Number	Length of Record
Chicago(1)	14881 (Downtown)	1/1/01 - 12/31/25
	14892 (University)	1/1/26 - 6/30/42
	14819 (Airport)	7/1/42 - 12/31/48
St. Louis	74603	1/1/08 - 12/31/52

(1) Location of station per official recording of U. S. Weather Bureau records for Chicago.

Card Data

The editing and punching of data for the substations on 1009 cards have continued in the same manner as described in the First Progress Report, with one exception. For an analysis project using the cards of four stations, a few of the blank columns beyond column 45 (columns 46-80) were punched. The purpose and procedure for this project are described in the Appendix, Part 7.

For the Chicago records, the editing procedures and data entry were identical to those described for Springfield in the First Progress Report. However, portions of the original Chicago records differed from the Springfield records and required special punching instructions. These instructions for 1901, 1902-1904, and 1943-1948 are listed in the Appendix, Parts 1, 2, 3, and 4. The St. Louis, Missouri, cards have the data entries used by the Missouri Cooperative Project[1].

Card Supplies

During the 12 month period covered by this report, 389,250 of the No. 1009 cards and 17,520 of the No. 3 cards have been punched. Duplicate cards for the 1901-1948 period were produced for the United States Weather Bureau for the following stations: Aurora, Carlinville, Danville, Kankakee, New Burnside, Rushville, Sparta, Chicago, and Springfield. The remaining duplicate cards will be completed in the near future.

TABLE III

CARD SUPPLY AND EXCHANGE LISTING
July 1, 1955-June 30, 1956

Card Type	Number Received(1)		Number Punched	
	Punched(2)	Unpunched	Original	Duplicates Shipped (1)
No. 1009 IBM 782918	55,000	500,000	389,250	114,610
No. 3 IBM 791616 or 762656	none	70,000	17,520	35,040
No. 1 IBM 770759	310,000	none	none	none
No. 5 IBM 802378	44,000	none	none	none
Monthly Summary, IBM 796158	none	10,000	none	none
TOTALS	409,000	580,000	406,770	149,650

(1) In reference to NWRC, Asheville, North Carolina.
(2) The stations for which punched cards were received are listed in Table IV.

The status of the Illinois project in regard to the number of cards received, punched, and duplicated is shown in Table III. The punched No. 1 and No. 5 cards, listed in Table IV, have been acquired because they were necessary to certain research projects.

TABLE IV

STATION CARDS RECEIVED FROM U. S. "WEATHER BUREAU
1 July 1955-30 June 1956

Cards	Stations
1009 Cards (1/1949-12/1/1954 period) -	Anna, Aurora, Bloomington, Belleville, Carbondale, Carlinville, Danville, DuQuoin, Greenville, Griggsville, Havana, Kankakee, McLeansboro, Mt. Carroll, New Burnside, Olney, Ottawa, Paris, Rushville, Sparta, Walnut, White Hall, and Windsor.
No. 1 Hourly Cards (periods per station) -	Chicago 1/49 thru 6/55 Springfield 1/49 thru 6/55 Peoria 1/48 thru 12/53 Moline 1/48 thru 12/53 St. Louis 1/48 thru 12/55
No. 5 Cards (3/53 thru 12/55) -	Nashville, Tennessee; Columbia, Missouri; Rantoul, Illinois; and Green Bay, Wisconsin

OPERATIONAL METHODS AND PROCEDURES

Procedures

Severed changes were made in the operational procedure of the Illinois project during the second report period. After considerable analysis of the 101 Statistical machine card checking methods, as described in detail in the First Progress Report, it was apparent that the value of verifying punched cards was negligible. A card with any serious errors could not pass through the 101 machine reject test and the 101 machine annual data printout listing without being detected. Errors in the magnitude of the temperature entries were the only possible ones that could be missed. The 101 machine reject test examines temperature entries of each card to see that: (1) the maximum exceeds the minimum, (2) the maximum equals or exceeds the set maximum on the same day of observation and the day prior, and (3) the minimum is equal to or less than the set maximum of the same day of observation and the day prior. However, if an acceptable maximum temperature of 89 F was mistakenly punched as 99°F, the 101 test would not detect the mistake.

Careful editing, especially on poor or illegible entries, eliminates almost all possibility for incorrect temperature entries. Consequently, station card decks were

not verified after the completion of the Chicago, Aurora, Danville, Rushville, Sparta, Walnut, and Windsor card decks. Card records for the above listed stations and those listed as punched in the period covered by the First Progress Report were the only Illinois station card records verified.

Other changes were inaugurated in addition to elimination of the verifying. A type 024 numerical keypunch was obtained for use in card punching and was located at the Survey in January 1956, after which date, no further card punching was done at the University of Illinois Statistical Service Unit. By having the editing and keypunching activities in one location, it was possible to expedite the whole punching process. Under the new procedure, after the editing and punching were completed, the cards were taken to the Statistical Service Unit for the 101 machine reject test. Thereafter, the procedure was the same as described in the First Progress Report, pages 13-15.

An allocation of time required for the 101 machine card tests is presented in the Appendix, part 5. Table V presents the statistics concerning the cause of errors obtained in the 101 machine preliminary annual printouts for the stations completed during this period.

TABLE V

ERRORS DISCOVERED FROM DISCREPANCIES BETWEEN TYPE 101 PRINT-OUT FROM CARDS AND PUBLISHED U. S. WEATHER BUREAU DATA FOR 24 ILLINOIS STATIONS

Subject (Annual Totals)	Errors on Cards	Errors in USWB Data	Total Errors
Precipitation	85	20	105
Snowfall	23	26	49
Number of Days Precipitation $\geq$ .01"	30	36	69
Total Errors	138	82	220

The distribution and cause of errors are presented for comparison with the same tabulation from the First Progress Report, page 15, Table IV. A total of 3345 separate comparisons between the 101 printouts and the United States Weather Bureau published data of annual precipitation, annual snowfall, and number of days of precipitation of 0.01 inch or more was made for the 24 stations. Of these 3345 comparisons, 220 did not agree and were classified as errors or discrepancies. However, 37 per cent of these 220 discrepancies were due not to card mistakes but to errors in the printed United States Weather Bureau data. This percentage is of the same magnitude as that reported in the First Progress Report.

Personnel

Throughout this period the editing, project supervision, and error checking required an Editor on three-fourths time basis. The equivalent of one keypunch operator was maintained as one full-time person rather than two or three part-time people. The experienced full-time keypunch operator averaged from 11 to 12 station-years for eight working hours. The equivalent of one, half-time machine operator for card analysis was maintained during this period. This operator handled all 101 machine card checks in addition to the other card research projects.

Card Costs

Eliminating the verification procedure helped to reduce cost of card production for this 12-month period. The average cost of punching and checking was 1.1 cents per card for the first report period, but for the present report period it was 0.5 cent. Other reasons for the saving in cost were that the Editor and keypunch operators were located at one place and that the keypunch operators had become more experienced.

WEATHER CARD RESEARCH PROJECTS

The amount of analysis utilizing the IBM weather cards increased considerably during this report period with five major projects underway.

101-Machine Sorting of Daily Precipitation Amounts

Using the 101 statistical machine, the cards from each station were sorted by precipitation amounts. Sixty intervals were selected for arraying the rainfall amounts. The interval selected was 0.10 inch for daily amounts ranging from 0.01 through 3.00 inches. The interval was increased to 0.20 inch for the range of 3.01 through 6.00 inches, and an interval of 1.00 inch was used for daily values from 6.01 through 11.00 inches. This sorting of daily amounts is adaptable to several different analyses of rainfall distribution.

From these sorted tabulations, computations for different length recurrence intervals of excessive, 24-hour amounts were made for each station. These 24-hour amounts are for periods ending at the standard observation times and do not represent the absolute maximum 24-hour amounts. Thus only daily summary card data were used with 24 hours between observations. The United States Weather Bureau has made similar sortings for 24-hour amounts of maximum precipitation[2]. regardless of the observation time. Their results for Illinois first-order stations show a close relationship to the results obtained by the Water Survey for the same first-order stations using the 24-hour period from midnight to midnight.

To ascertain the statewide areal variations in the recurrence intervals 2-, 5-, 10-, and 25-year maps were plotted from the card data printouts and are shown in Figure 2. The maps indicate that for these intervals, Southern Illinois can expect higher amounts of daily precipitation than elsewhere in the state, with a decrease in intensity northward and eastward similar to the distribution of annual precipitation in Illinois.

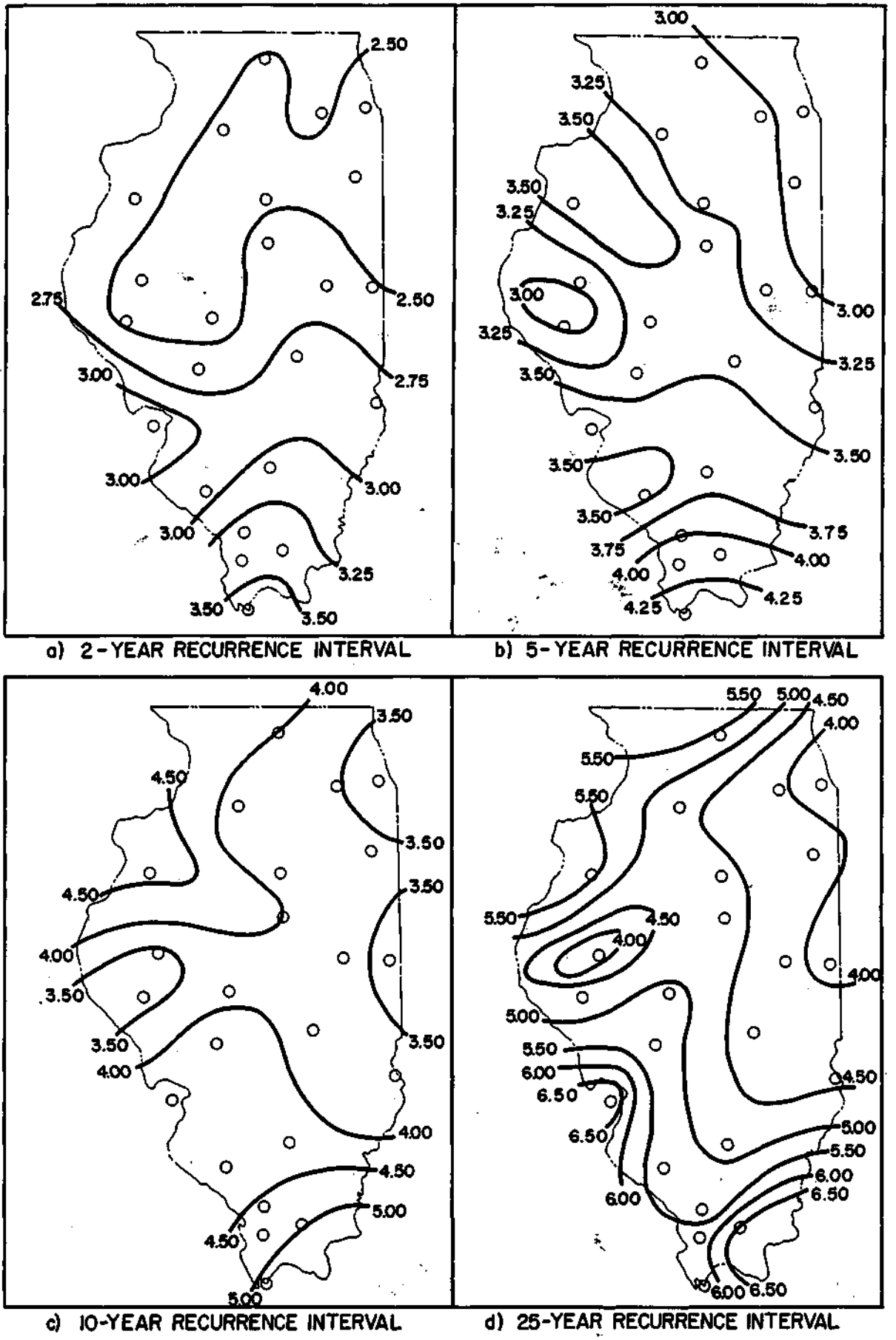

FIG.2 RECURRENCE INTERVALS FOR MAXIMUM DAILY PRECIPITATION

These recurrence intervals are presented in yearly intervals, which are a partial-duration series, not sortings of the maximum 24-hour amounts of each year (referred to as annual duration series). In the partial-duration series all of the large amounts in the 50 years of record are ranked, and with such a sorting, it is possible that two or more of the excessive 24-hour amounts used in the rankings occur in the same year. Thus, different recurrence intervals are obtained from annual duration and partial-duration series.

The partial-duration series' analysis for maximum expected precipitation is frequently desirable, but usually cannot be accomplished since it is quite laborious to do manually. However, the 101 machine can sort and rank all the daily precipitation amounts from 50 years of records for approximately 20,000 cards in 2-1/2 hours.

The United States Weather Bureau[2] indicates that empirical factors for transforming the partial-duration series results to annual series results have values as follows: divide the 2-year partial values by 1.13, the 5-year by 1.04, the 10-year by 1.01; and for longer periods, the difference between the two series is insignificant. Therefore, the values of the 10- and 25-year recurrence maps as shown would be about the same for the annual duration series, but some differences would appear in the values on the 2- and 5-year partial-duration recurrence maps.

Thunderstorm Climatology of Illinois

Climatological analysis of daily thunderstorm datafor Illinois was accomplished using the IBM weather cards. The purpose was: (1) to describe in detail the occurrence of thunderstorms in Illinois on an annual and monthly basis, (2) to describe thunderstorm precipitation (annually and monthly) as to actual amounts and in relation to the average precipitation, and (3) to ascertain the relationships between the occurrence of thunderstorms and hail and sleet on an areal basis.

Since first-order stations in Illinois are too sparse to obtain the areal detail needed for this type of climatological study, substation data on thunderstorms had to be included. It was found that portions of substation "days with" data on thunder, hail, and sleet could be used in such an analysis if the records were carefully examined and tested. Next, corrections for error and missing data were ascertained for thunderstorm frequency comparisons between the first-order stations and substations. Analysis indicated that if all thunderstorm occurrences resulting in 0.09 inch or less precipitation for the daily total were subtracted from the respective substation and first-order station totals, the magnitude of the counts for both station types was in good agreement. A method was then devised for computing thunderstorm precipitation at substations to furnish average amounts equivalent to nearby first-order stations. Such a method was necessary since at substations the precipitation observations were recorded at 5 or 6 PM, and the thunderstorm observations were recorded at the end of the day or the observer's bedtime.

The problem was resolved by including the amount on the day of the thunderstorm as well as the day following with the data being processed on the 407 tabulator. This study illustrates the use of cooperative substation "days with" data.

Cloud Census Project for Illinois

During the past six months a study of the cloud climatology of Illinois has been in progress through the use of Type No. 1 hourly cards from first-order stations. This work is in a preliminary stage. The purpose of the study is to obtain a basic description of the frequency and amount of cloud types over Illinois and attempt to learn what relationship exists between the cloud types and precipitation occurrence.

Over 200,000 Type No. 1 hourly cards for Chicago, Springfield, Moline, and Peoria have been analyzed. These cards represent hourly data for periods from 1948 through 1955 as indicated in Table IV. On the Type No. 1 card, cloud types and their amount of sky coverage at each hour are entered. On the Type No. 1 hourly cards the United States Weather Bureau entered data on 14 different cloud types. Recorded for the low-cloud category were stratus, nimbostratus, stratocumulus, cumulus, and cumulonimbus. In the middle-cloud category were alto-

TABLE VI
CLOUD TYPE FREQUENCIES 1948-1955
Annual Frequency of Hourly Occurrences

Cloud Types

	Cb	Cu	Sc	As	Ac	Ns	CiCsCc	Total
Chicago	60	732	2624	538	2068	54	2169	8245
Moline	225	883	1586	598	1891	83	1760	7026
Springfield	205	885	2257	230	2625	90	2438	8730
Peoria	220	873	2111	254	2495	240	2506	8699

Annual Frequency of Hourly Occurrences Expressed
As Percent of Possible Observations

Cloud Types

	Cb	Cu	Sc	As	Ac	Ns	CiCsCc
Chicago	0.7	8.4	30	6.1	24	0.6	25
Moline	2.6	10.0	18	6.9	22	0.9	20
Springfield	2.3	10.1	26	2.6	30	1.0	28
Peoria	2.5	10.0	24	2.8	28	2.7	29

stratus and altocumulus, while the major types in the high-cloud category were cirrus, cirrostratus and cirrocumulus. The other less important types entered on the cards were altocumulus castellatus, cumulo-mammatus, fracto-cumulus, and fracto-stratus. Each hourly card provides four layers of possible cloud types. The cloud type and amount in each layer are entered in separate card columns. This type of record makes analysis very difficult since most cloud types are entered in more than one layer on different cards. Consequently, all cloud data were summarized by layer per day before complete daily totals for each cloud type could be obtained.

On the final summary cards entries were made for all cloud types and their amounts. This machine procedure is described in detail in the Appendix, part 6. Table VI presents the annual frequencies of the various basic cloud types which were analyzed in this study.

Preliminary results of correlations between the various cloud types and monthly precipitation amounts at Springfield are presented in Table VII.

TABLE VII

CORRELATION COEFFICIENTS OF MONTHLY RAINFALL WITH NUMBER OF CLOUD OCCURRENCES AND CLOUD AMOUNTS AT SPRINGFIELD, 1951-55

	SUMMER		FALL-SPRING		WINTER	
	May-September		October, November, March, April		December-February	
Cloud Type	Number of Hourly Occurrences	Summation of Hourly Amounts	Number of Hourly Occurrences	Summation of Hourly Amounts	Number of Hourly Occurrences	Summation of Hourly Amounts
Cb	0.70	0.59	0.50	0.42	0.24	0.22
Cu	0.20	0.17	0.36	0.33	0.21	0.21
Sc	0.37	0.27	0.16	0.20	-0.56	0.04
Cu, Sc, Cb	0.50	0.40	----	----	----	----
St, Fs	0.33	0.25	0.41	0.44	-0.02	-0.05
As	0.80	0.76	-0.001	-0.03	-0.15	-0.04
Ac	0.37	0.34	-0.02	-0.12	-0.22	-0.15
Ci, Cc, Cs	0.60	0.60	0.30	0.17	-0.12	-0.22

A third phase of the cloud census work concerned obtaining a detailed analysis of the daily cloud conditions prior to the development of cumulonimbus in Illinois, since cumulonimbus appeared to have the best correlations to precipitation at all stations for all seasons. This analysis was made on the basis of three categories: (1) cumulus observed every hour from 1200 until the cumulonimbus was observed with no prior high clouds present, (2) high clouds (Ci, Cs and/or Cc) observed

every hour from 1100 until the cumulonimbus was reported, (3) and any condition of non-continuous cloud forms occurring prior to cumulonimbus development. The only significance in the results of this analysis for Chicago, Springfield, and Moline is that the days with cumulus reported from 1200 on, and with no high clouds prior to the cumulonimbus, averaged less rainfall than days with high clouds prior to the cumulonimbus. These results are shown in Table VIII.

Correlation of the cumulonimbus with precipitation on a daily basis shows no better agreement than it did on a monthly basis. These cloud studies will be continued with data from St. Louis, Missouri, and Terre Haute and Evansville, Indiana, to provide a more inclusive census for Illinois.

Radiosonde Program for Studying Upper Air Moisture Conditions

A comprehensive study of the atmospheric moisture at different levels over Illinois in relation to precipitation occurrence has been initiated. An earlier study which was accomplished manually suggested numerous investigations which can now be done readily with high-speed computing machines. Type No. 5 cards from four radiosonde stations in the Middle West were acquired, as shown in Table IV. Results of this study are not yet available.

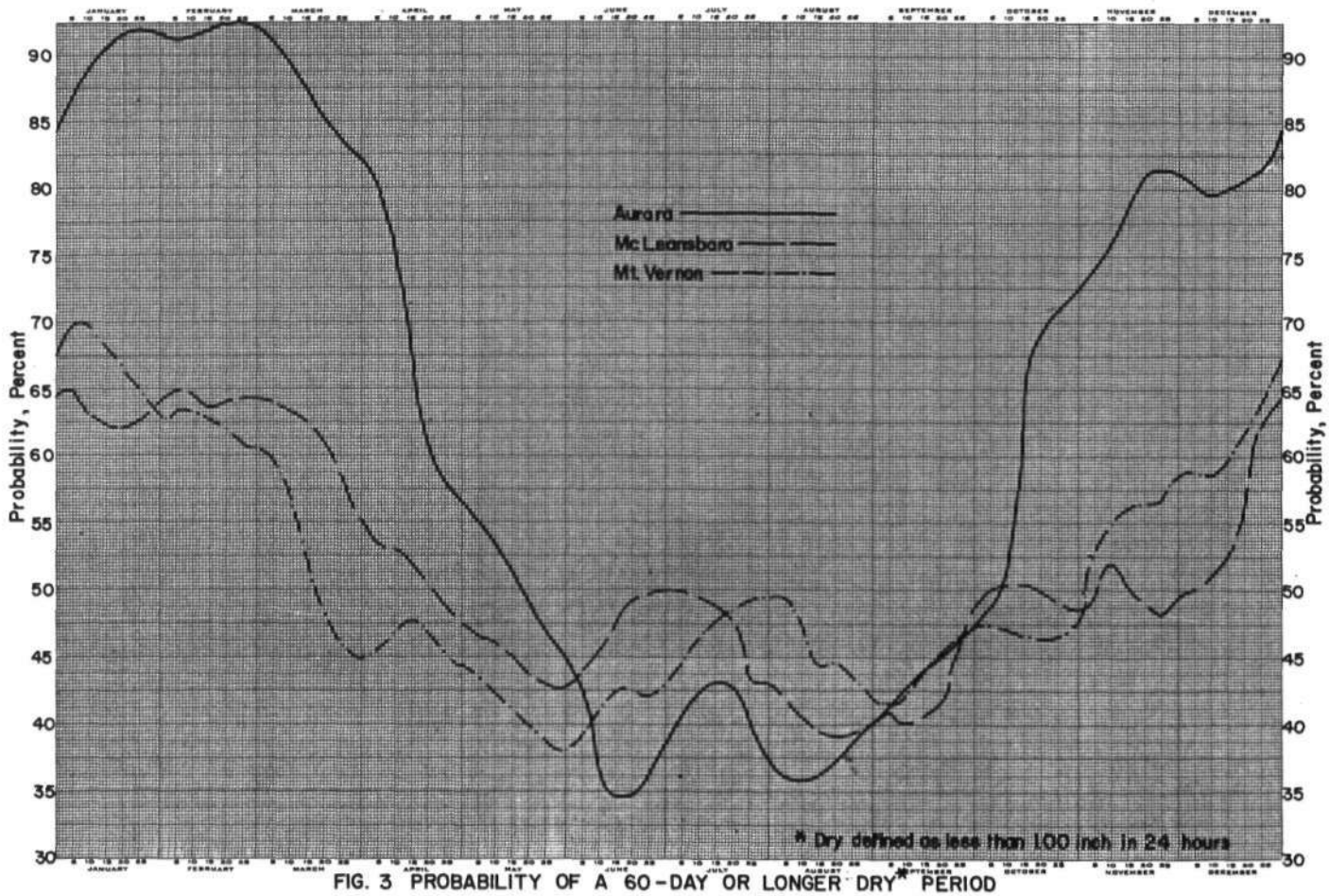

FIG. 3 PROBABILITY OF A 60-DAY OR LONGER DRY* PERIOD

TABLE VIII

CUMULONIMBUS RELATIONSHIPS TO DAILY PRECIPITATION 1951-1955

Daily Prior Condition	Chicago			Springfield			Moline*		
	Number of Cases	Percent of Total Cases	Average Rainfall per Case	Number of Cases	Percent of Total Cases	Average Rainfall per Case	Number of Cases	Percent of Total Cases	Average Rainfall per Case
CuCb(1)	10	11	0.34	24	10	0.15	25	17	0.29
Ci**Cb(2)	19	21	0.45	44	18	0.26	13	9	0.39
Cb(3)	62	68	0.60	175	72	0.28	107	74	0.39

* 1951-1953 data only.
** Ci and/or Cs and/or Cc.

Definitions of Daily Conditions Antecedent to Cb

(1) CuCb condition: Had continuous hourly observations of Cu from 1200 CST until first Cb reported with no Ci, Cs, or Cc reported at any hour in that day prior to Cb.

(2) CiCb condition: Continuous hourly observation of Ci, Cc, or Cs from 1100 CST until Cb first reported, with or without Cu in prior hours.

(3) Cb condition: Prior hours could have Cu, Ci, Cs, or Cc, but no continuous hourly sequence of any types.

Wet-Dry Analysis Program

In order to investigate the probabilities for continuous wet and dry periods, expressed in degrees of "wetness" or "dryness," an extensive analytical project was begun utilizing the Type 1009 daily summary cards. The purpose of the analysis was to determine the probability of each date occurring in any length of a wet or dry period. An example of the probability curves of three stations for each date in the year being in a 60-day or longer dry period is shown in Figure 3. In this illustration, a "dry" day is defined as one having less than one inch of rain.

A method of analysis by IBM machine was developed to accomplish the wet and dry computations simultaneously. A detailed description of this method is given in the Appendix, part 7. The four levels selected for "wet-dry" definition were 0.10 inch, 0.25 inch, 0.50 inch and 1.00 inch.

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2. Anon., "Rainfall Intensity-Duration Frequency Curves," U. S. Department of Commerce, Weather Bureau, Technical Paper No. 25. Washington. D. C, 1955.

3. Changnon, S. A., Thunderstorm-Precipitation Relationships in Illinois. Submitted in partial fulfillment of the requirements for Master of Science Degree in Geography at the University of Illinois, 1956.

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APPENDIX

I. Instructions for Punching Chicago Records for 1901

The Chicago records for 1901 differ from the other years in that the daily data for each month are partially summarized on one page; however, four different pages are required for each month's data. One month's data Were punched from one page, the cards were returned to the key punch, and this method of punching was repeated for each page.

The data are found in one book with eight pages presented for each month, all numbered. The data in this book as punched and page numbers applying to each month follow:

a. Page 6 of each month has:
   1. Daily maximum temperature.
   2. Daily minimum temperature.
   3. Precipitation from 8 PM - 8 PM (actually 7 PM - 7 PM).
   4. Snowfall from 8 PM - 8 PM (actually 7 PM - 7 PM).
   5. Snow depth on ground at 8 PM.

b. Page 2 of each month has 7 AM observations of:
   1. Barometric pressure reduced to sea level (disregarding the 5th or thousandths digit).
   2. Relative humidity at 7 AM.

c. Page 3 of each month has 7 PM observations of:
   1. Barometric pressure reduced to sea level.
   2. Relative humidity
   3. "Days With" phenomena, either encircled or stamped on.

d. Page 5 of each month has the total wind movement to be entered rather than average wind velocity with no decimals. If movement over 999, x was punched for 1000 and the other numbers were punched in the three columns. For instance, 1910 movement would have an x overpunch plus 9, 1, and 0 in the three columns.

e. There are no hours of sunshine, per cent of sunshine, nor prevailing wind directions, so these columns were left blank.

2. Chicago Punching Instructions for 1902-1904

Each day has a separate page with the following data:

a. The maximum and minimum temperatures are written inside the temperature graph.
b. Precipitation from midnight-to-midnight is found to the right of the words, "Total Precipitation."
c. If snowfall occurred, the amount is written above the word "Precipitation."
d. Snowdepth is listed below the line of wind direction and written: "Snow on ground."
e. No entries of sea level pressures for 7 AM and 7 PM.
f. Relative humidity readings for AM and PM are found in center of page written in the blanks of an ink stamp: "Humidity 7 AM--- 7 PM----."
g. "Days with" events are stamped near the center of page.
h. Daily prevailing wind direction is on the right side of page. If more than one direction was listed, the second was used.
i. Daily average wind velocity is listed just above wind direction. Since 1902 only whole numbers are used, a zero was punched in the tenths column. However, for 1903-1904, the tenths are given and were punched.
j. Per cent of sunshine is given on the right side of the daily page and entered just above it are the hours of sunshine.

3. Supplementary Chicago Instructions 1905-1942

a. Snowfall entries are on a midnight-to-midnight basis beginning in 1909.
b. Beginning in 1905, the sea level pressures in the AM and PM are entered.
c. Beginning in 1916, a 2 PM relative humidity reading is stamped in and encircled for punching rather than the 7 PM as for 1901-1915. After 1917 these PM relative humidity readings are at 12 noon.
d. Beginning in 1926, the records for each year are contained in two books, with January to June in the first volume and July to December in the second.
e. There are two pages for each date beginning 1 January 1926., with the first page of the two serving as the official entry for punching data. The official page for 1926 through 30 June 1942 contains University of Chicago Observatory data. From 1 July 1942 until 1 January 1943, the official data were taken at the Chicago Municipal Airport Station.
f. Beginning in 1943, the Weather Bureau used one book for each year and special punching instructions were necessary.

4. Chicago Punching Instructions for 1943-1948

a. All entries except the two relative humidity and two pressure entries are on individual pages as per records prior to 1943. Beginning in 1944, the entry for actual sunshine lists sunshine in hours and minutes. However, these data were translated to hours and tenths, and the figures were written in pencil just below the hours and minutes entry.
b. The relative humidity and the pressure figures are on separate pages, each containing entries for a total month. These sheets are in the front section of each book.

(1) Starting in 1944, the barometric pressure reduced to sea level is given in millibars instead of inches and was punched as follows:
1026.8 = x overpunch for the initial digit and the other 4 entries were put in the four columns thusl'y: 0, 2, 6, and 8.
926.8 = No x overpunch and 4 entries were 9, 2, 6 and 8.
(2) The AM relative humidity and pressure are found on page 2 in all months.
(3) The PM relative humidity for 1:30 PM is found on page 3 of each month.
(4) The PM pressure reading for 7:30 PM is given on page 4 of each month.
(5) The column headings for the months were checked in pencil to indicate their location.

c. In punching, all data were entered from the individual daily sheets for the complete year, and then the pressure and relative humidity data were punched by months in a second pass of the cards through the keypunch.

5. Estimated Time Required for Analysis Projects

The following estimates are based on 10,000 cards as base amounts unless stated otherwise and include time for handling of cards and board changes.

		Hours	Minutes
a.	**Punching Monthly Summary Cards from 1009 Daily Summary Cards.**		
(1)	Calculating degree days (on 1009) on 604	3	0
(2)	First pass through tabulator 407	4	0
(3)	Second pass through tabulator 407	4	0
(4)	Reproducing summary data from second pass onto summary cards from first pass	0	40
(5)	Calculating mean temperatures on 604 calculator	1	0
(6)	Correction of cards	1	0
(7)	Listing of final summary cards	0	20
	Total	13	60
b.	**Reject Card Checks on 101 Machine (1009 cards)**		
(1)	Checking (running through)	1	0
(2)	Correction of reject cards, depends upon amount, approximately	0	15
(3)	Refiling reject cards	0	30
	Total	1	45
c.	**Preliminary Printout on 101 Machine (1009 Cards)**		
(1)	Processing and printing	1	0
(2)	Checking precipitation and snowfall errors (average 15 minutes per year) of cards	7	0
	Total	8	0
d.	**Final Printout on 101 Machine (1009 Cards)**		
(1)	Processing and printing for one station of 50 years record	1	30
	Total	1	30
e.	**Precipitation Intensity Sortings on 101 Machine (1009 Cards)**		
(1)	Sorting and printout	1	20
	Total	1	20

		Hours	Minutes
f.	**For Dry-Wet Period Analyses (1009 Cards)**		
(1)	Sorting cards in order	0	55
(2)	Calculating on 604	6	0
(3)	Gang-punching on 604	3	0
(4)	Preliminary sorting on 101	0	40
(5)	Final sorting on sorter	0	55
(6)	Merging "9M" cards on collator	1	15
(7)	Final printout on 101	7	0
	Total	19	45
g.	**Frequency Cloud Count on 101 Machine (No. 1 Cards)**		
(1)	Processing time	1	0
	Total	1	0
h.	**Cloud Amount Summary Punching onto Daily Cards on 407 Tabulator (from No. 1 cards)**		
(1)	Checking sequence on 101 machine.	1	0
(2)	Processing cards through 407 each pass (5 passes made) is 7 hours.		
	Total for all passes	35	0
(3)	Merging summary cards on collator	2	0
(4)	Final printout on 407	0	30
	Total	38	30
i.	**Final Printout on 407 Tabulator for First-order stations**		
(1)	Processing for one station	3	0
	Total	3	0

6. Description of the Illinois Cloud Census Analysis Project Using No. 1 Hourly Cards

The No. 1 cards in chronological order were processed by the 101 statistical machine to obtain a frequency cloud count. A monthly total printout of the occurrences of each cloud type for each of the four layers was obtained. This information was also summary punched on blank cards. All the cards with or without cloud entries are passed through the 101 machine.

The second phase of the cloud census analysis concerns (1) obtaining daily and monthly cloud type amounts, and (2) classifying the daily cloud conditions prior to cumulonimbus into three categories. To perform these analyses it was necessary to have cloud data entered on all hourly cards. The Type No. 1 hourly cards prior

to 1 June 1951 have cloud data entered every third hour, but after this date, hourly cloud data were entered. Therefore, these analyses were performed on data after 31 May 1951. The cards were kept in correct chronological sequence which was checked on the 101 statistical machine using a sequence check board.

The 407 tabulator is connected to 514 reproducer to enable the punching of data on blank summary cards. The hourly cards were passed through the tabulator to produce daily summary cards (midnight-to-midnight) which contained amounts of all cloud types from layer 1 of the 24 hourly cards, and simultaneous printout was made. The process was repeated for layers 2, 3 and 4 by altering the tabulator board wiring. Then, all the amounts of cloud types from the four different layers were summarized into decks of daily cards.

Next, the cards were tested for the daily cloud conditions prior to cumulonimbus. These conditions are described on page 14. This was accomplished on the tabulator with a summary card punched for days with cumulonimbus. Each card has an indication of the type of prior condition on that day.

The decks for the four layers were merged in sequence by layers on the 077 collator. Two separate mergings were required, one for the layer 1 and layer 2 daily summary card decks and another for the 3 and 4 layer decks. The few summary cards for cumulonimbus prior condition were inserted by hand.

The deck of the combined five daily summary cards was then passed through the tabulator and complete daily summary cards punched in the reproducer. All the amounts and the cumulonimbus conditions from the intermediate decks were combined on one complete daily summary card. A printout of the summarized daily values was made simultaneously with the various conditions prior to cumulonimbus indicated.

7. Description of the Illinois Wet-Dry Analysis Project Using 1009 Cards

If the 1009 cards were not in chronological order, they were sorted on the 082- sorter which required about 1-1/2 hours for 50 years of card records. All time estimated hereafter is for 50 years of daily summary cards.

If there were any breaks in the precipitation data from missing precipitation entries or periods of no records, these cards were removed and x-80 cards were inserted. An x-80 card has an x-overpunch in column 80. These x-80 cards served as "breaker cards" in the counting of the continuous conditions chronologically on the 604 calculator. If there were any data already punched in columns 46-55 and columns 70-79, new cards were produced with these columns left blank. Regardless of which columns are used for computations, 20 blank columns are required on the card for this project.

Computing the "wet-dry" condition and counting the sequences of continuous "wet" or "dry" days were accomplished on the 604 calculator.

The punch-reading section evaluated the precipitation data in columns 23-26 and classified the amounts during the chronological card pass (cards face down) as being "wet" or "dry" for the 0.10-inch and the 0.25-inch levels simultaneously. This information was indicated in card column 71 for the 0.10-inch level and in column 73 for the 0.25-inch level. If the day (or card) is "wet," it was indicated as such by an x-overpunch, and no overpunch was used to indicate "dry."

At the same time, the 604 calculator was also counting the continuous days of either "dry" or "wet" periods after each new card condition was met until the opposite condition, dry versus wet, was encountered on an ensuing card. At this time, or at the end of any given similar continuous condition of one day or more, the number of continuous days in the period was punched into the "period-ending card" in columns 70-71 for the 0.10-inch level and in columns 72-73 for the 0.25-inch level. This entire procedure required approximately four hours.

Another identical pass was made for indicating and calculating the conditions on the 0.50-inch level and 1.00-inch level. The x-overpunch, when necessary, was entered in column 76 for the 0.50-inch level and column 79 for the 1.00-inch level. The same wiring board was used with only a few wiring changes to handle the new columns used with the 0.50-inch and 1.00-inch levels.

The cards were next run through the 604 calculator for the third time. On this third pass, the cards were fed through the 604 in reverse, that is, face-up in the throat of the feeder. The purpose was to enter the number on each card (day) which represented the length of the continuous "wet" or "dry" period for that particular card. This number, prior to the third pass, appeared only in the "period-ending cards" and had to be entered in all the cards of the period to which it applied. For example, in the case of a group of six continuous "dry" days, the number "six" is entered in the following "wet" day or "period-ending card" that ended the 6-day "dry" period. Therefore, as the cards pass through backwards, the number recorded in the "period-ending card" is encountered by the machine. Next, this new number is entered in all the following cards until the continuous period again ends. All four levels of precipitation intensities were handled simultaneously in the third pass on the calculator, which required five hours to accomplish.

The card columns used for this gang-punching of the period number information in columns 70-79 for the 4-levels were columns 46-47 for 0.10-inch, columns 48-49 for 0.25 inch, columns 50-52 for 0.50-inch, and columns 53-55 for the 1.00-inch level. When this third pass in the calculator was completed, all the desired necessary data were entered on each card.

The number of columns used for each level was determined after sampling data from two different Illinois stations exhibiting maximum state-wide extremes in their annual precipitation amounts. These stations were Aurora in northeastern Illinois and McLeansboro in Southern Illinois. These preliminary studies indicated that for the 0.10-ineh and the 0.25-inch levels, two columns each or a count of up to 99 days were sufficient to handle the longest continuous "wet" or "dry" periods in the 1901-1954 period. For the 0.50-inch and the .1.00-inch levels, 3 columns

each or a count of up to 999 days was necessary to handle the longest continuous "wet" or "dry" periods.

The cards were now sorted into months, that is, all of the Januarys were combined, all of the Februarys, etc. The "breaker cards" were also sorted at the same time. This sorting was done on the 101 statistical machine and required one hour to perform.

The cards were now sorted for a third time by days (or dates) in the 082 sorter, and this operation required 1-1/2 hours. Now, all of ther first days of a particular month were combined, all the second days, etc. At this point, 366 blank cards with a "nine" gang-punched in column 80 were inserted by the collator on the 1009 cards, with one "9-80" card behind each card group of the same date. This enables the 101 statistical machine to print out the total distribution of data for each date. The collating operation required two hours.

On the 101 statistical machine, the final printout of the data was done with a separate printout for each level. The same wiring board was used for each level, and only the column wires were changed to get the printout data from columns 46-55 for the four different levels. Each final pass through the 101 machine required 3 hours or a total of 12 hours for all four levels used on each station analysis. The total time required to analyze a station having 50 years of records on 1009 cards, including all machine analysis and card handling, was approximately 32 hours.