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An Atlas and Tables of Thunderstorm and Hail Day Probabilities in the Southeastern United States

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SUMMARY

Maps and tables of thunderstorm and hail days probabilities based on selected stations in the southeastern United States are presented. These probabilities are estimated by either one of two discrete distributions, the Poisson or negative binomial. Analysis of monthly thunderstorm days indicates that the Poisson distribution is generally adequate for the summer months, when the occurrence of thunderstorms is greatest. The remaining months for thunderstorm days as well as the annual thunderstorm period do not show a consistent specific model selection. Overall, the distribution of annual hail days fits the Poisson distribution in the Southeastern States.

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INTRODUCTION

An important part of the climatology of any area includes thunderstorm and hail climatology. Of particular interest is the chance of a thunderstorm or hail day at any particular time of the year. This type of information is potentially useful for planning purposes especially with the ultimate goal of reducing the cost/benefit ratio for an enterprise where the occurrence of thunderstorm or hail is a factor.

Thunderstorm and hail days probabilities provide essential information for the design of watershed facilities to minimize the damage of flash flooding, which is often associated with thunderstorms. In addition, probability information can also be utilized in planning manpower requirements for public utilities, Weather Service Offices, and disaster relief agencies so that they can be better prepared to cover periods of peak severe weather and associated flash flooding. This is particularly true during the weather transition spring and fall months. The probabilities also provide potential information for farmers, construction companies and other such groups whose work can be delayed and whose equipment and materials can be damaged by thunderstorm and hail activity. For example, construction companies may want to stock a sufficient supply of protective covering for newly laid concrete during the months of frequent thunderstorm occurrence. Also, protective measures for sensitive equipment, which can

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easily be damaged by hail or heavy rain, should be dealt with during the planning stages. If the incidence of hail is low, the company may decide to withhold expenditures for protective measures. The probabilities would also be very useful in the long-range planning of recreational events, such as fairs and carnivals or picnics.

Insurance companies that offer crop hail insurance may also find the enclosed information useful in establishing premium rates.

Purpose of this bulletin is to provide severe weather climatological information on the occurrence of thunderstorm and hail days in the southeastern United States. The principal areas of investigation include the states of Alabama, Florida, and Georgia; however, information for some parts of Mississippi, Tennessee, and South Carolina is also included (see Figure 2). The technical approach in this study has been to estimate the probabilities of monthly and annual thunderstorm days as well as annual hail days for the study areas.

PREVIOUS WORK

Thunderstorm and hail days probabilities have been investigated by Kendall *(8)*, Falls, *et al.* *(5)*, Sakamoto *(11)*, and Davis *(4)*. The theoretical basis of these studies rests upon the work of Fisher *(6)* and Thom *(12)*. Kendall *(8)* used the Poisson distribution to calculate the probabilities of thunderstorm days for the months May through September at 18 locations in Canada. He calculated the negative binomial probabilities for a number of station months and compared these results with both the observed and Poisson probabilities. Kendall found that in some cases the negative binomial distribution provided a better fit; however, he also found that there was less difference between the two sets of theoretical frequencies than between the calculated probabilities and the observed frequencies of both distributions.

Falls, *et al.* *(5)*, investigated several distribution functions in his search for a model to represent the distribution of thunderstorm activity at Cape Kennedy, Florida from January 1957 through December 1967. The Poisson and negative binomial distributions were both tested to see how they fitted the observed thunderstorm data. The data were processed by the month and by the four seasons. These results showed that, for all the data sets tested, the sample variance exceeded the sample mean. The

x^2 "goodness of fit" test was used to test the results and revealed that the negative binomial distribution provided a better fit than the Poisson.

Sakamoto *(11)* calculated the probabilities of monthly thunderstorm days and annual thunderstorm and hail days for Nevada. His computer program, using techniques described in this paper, selected either the Poisson or negative binomial method as the theoretical model which best fitted the observed data. The results were tested using the distribution-free KS test discussed by Massey *(10)*. Davis *(4)*, using the Sakamoto program (with slight modifications) calculated the probabilities for the monthly periods in Ohio.

PROCEDURE

An outline of the method of model selection is presented in Figure 1. After the data is read into the program, its distribution is tested according to the test by Thom *(13)* to see if it can be accounted for by the Poisson distribution. If the Poisson distribution is chosen, the probabilities are calculated and the next data set is read in. If the Poisson distribution is found to be inadequate, the negative binomial distribution is considered. The parameters in this distribution are calculated first by the method of moment. If this procedure is found to be inefficient, a maximum likelihood method for calculating the distribution parameters is used. The probabilities are calculated and the next data set is read in. A listing of the computer program to calculate the probabilities can be found in Davis *(4)*. The Appendix in this report contains a detailed discussion on the distinction between the Poisson and negative binomial distribution, computational procedures with the computer program and the testing of the calculated and observed data.

DATA

The data for this study were obtained from the National Weather Service Climatological Record Books. An entry for thunderstorm or hail is made in these books in accordance with Federal Meteorological Handbook No. 1—Surface Observations (1971). A thunderstorm is considered to begin at a station when thunder is head, or when overhead lightning or hail is observed and the local noise is at such a level as might prevent the hearing of thunder. Hail is defined as precipitation consisting of small balls of ice or other pieces of ice falling separately or in irregular lumps which

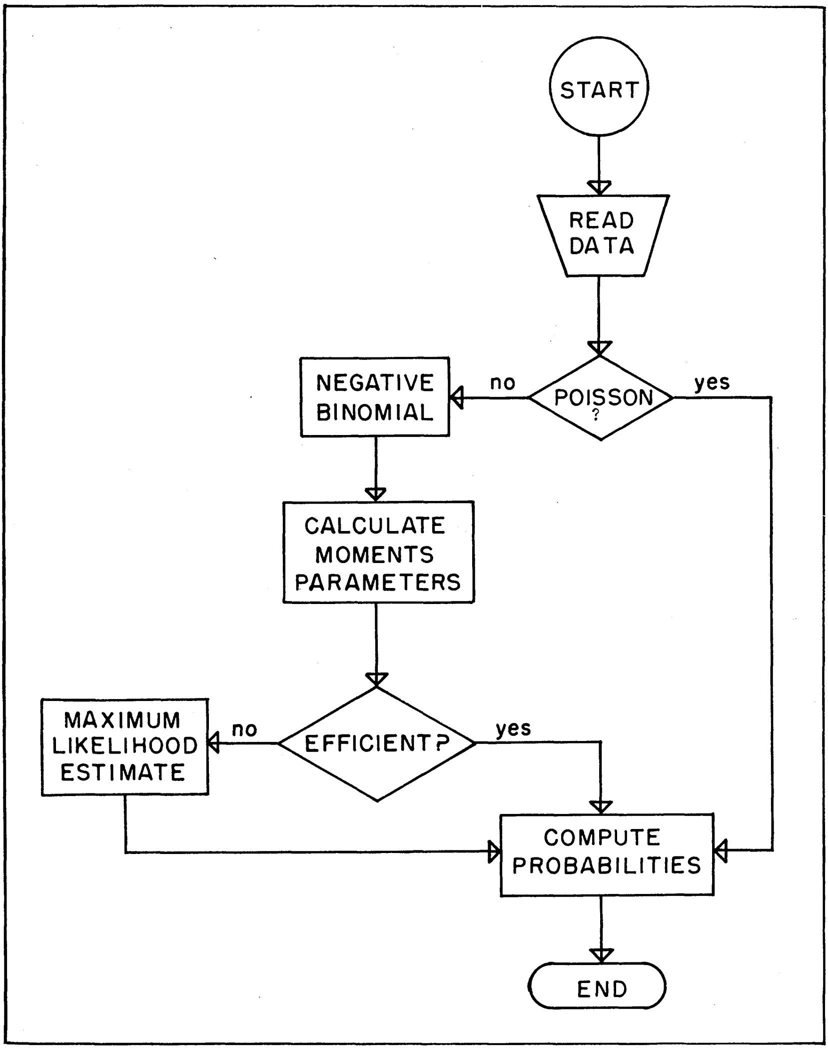

FIG. 1. Flow diagram for computer program of thunderstorm and hail study.

TABLE 1. STATIONS AND PERIOD OF RECORD FOR THE SELECTED STATIONS

Alabama	
Anniston	1906-1930
Birmingham	1941-1970
Mobile	1941-1970
Montgomery	1941-1970
Florida	
Apalachicola	1941-1970
Daytona Beach	1951-1970
Fort Myers	1951-1970
Jacksonville	1941-1970
Key West	1941-1970
Lakeland	1941-1970*
Miami	1941-1970
Orlando	1951-1970
Pensacola	1941-1970
Tallahassee	1941-1970
Tampa	1941-1970
West Palm Beach	1951-1970
Georgia	
Athens	1941-1970
Atlanta	1941-1970
Augusta	1941-1970
Columbus	1951-1970
Macon	1941-1970
Rome	1951-1970
Savannah	1918-1947
Thomasville	1951-1970
Mississippi	
Meridian	1941-1970
South Carolina	
Charleston	1941-1970
Columbia	1951-1970
Greenville	1941-1970
Tennessee	
Chattanooga	1941-1970
Knoxville	1941-1970
Nashville	1941-1970

* Hail days only 1951-1970.

have been frozen together. Normally hail is associated with thunderstorm activity. The occurrence of either or both of these phenomena on a given day constitutes either a thunderstorm day, a hail day, or a thunderstorm and hail day. Thus the study is concerned with finding the probabilities of the numbers of thunderstorm and hail *days* and not with the probabilities of the total number of thunderstorm and hail occurrences. For example, if more than one thunderstorm occurred on one day, this would still constitute one thunderstorm day.

In Table 1 the stations are listed that were used in this study along with the period of record for each station. Figure 2 is a

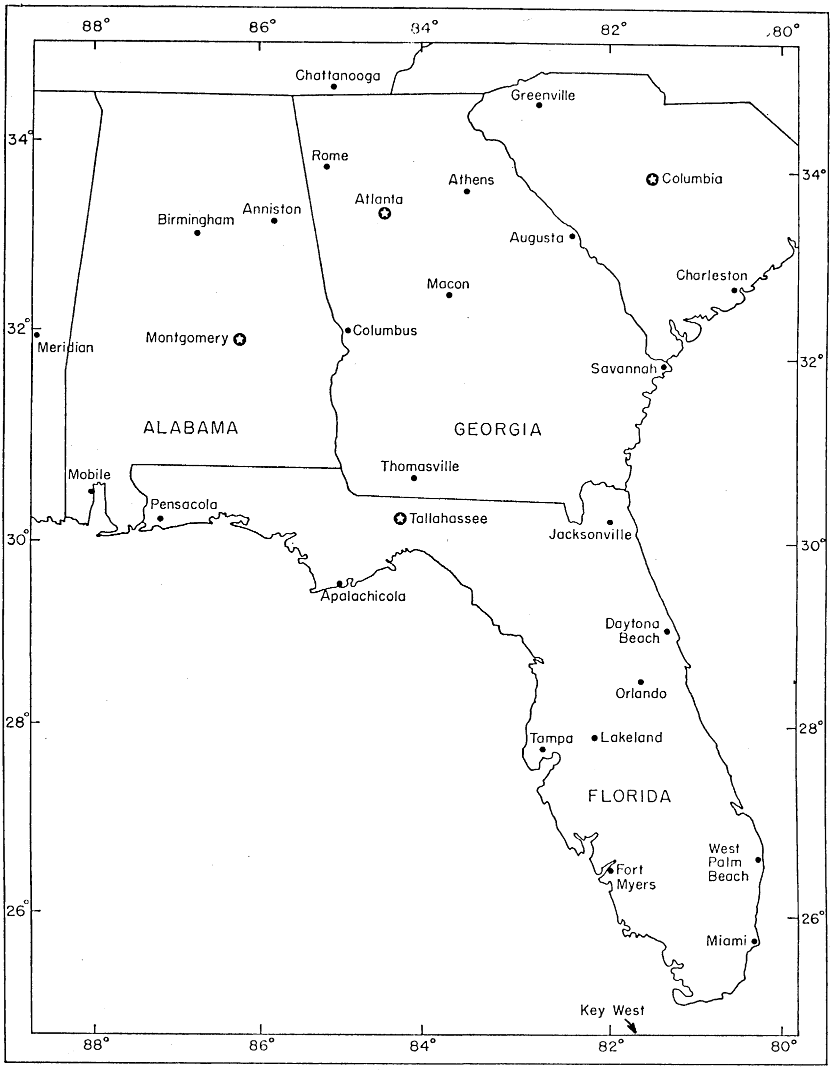

FIG. 2. Station location map.

location map for the stations involved. Approximately two-thirds of the 31 stations had data available for the 30-year period, 1941-1970. Most of the remaining stations were established during the late 1940s and early 1950s. In all cases, the assumption is made that climatologically, there has not been any significant frequency changes of thunderstorm and hail days during the different series of years. It should be noted that most Florida stations are located on the coast.

RESULTS AND DISCUSSION

Model Selection

Table 2 shows the results of the model selection for thunderstorm and hail days in the study area. A general observation is that for the summer months (June, July, and August), the Poisson distribution is adequate. Furthermore, in both Alabama and

TABLE 2. MODEL SELECTED FOR MONTHLY AND ANNUAL THUNDERSTORM DAYS AND ANNUAL HAIL DAYS FOR SELECTED STATIONS IN THE SOUTHEASTERN STATES

	Month												Annual	
	J	F	M	A	M	J	J	A	S	O	N	D	T*	H*
ALABAMA														
Anniston	P+	P	N	P	P	P	P	P	N	N	P	N	N	P
Birmingham	P	N	P	P	P	P	N	P	P	P	P	P	P	P
Mobile	P	P	P	P	P	P	P	P	N	P	N	P	P	P
Montgomery	N	N	P	P	P	P	P	P	P	P	P	P	P	N
FLORIDA														
Apalachicola	N	P	P	P	P	N	P	P	N	P	P	P	N	P
Daytona Beach	P	P	P	P	N	P	P	P	N	N	P	N	N	P
Fort Myers	N	P	N	N	N	P	P	P	P	N	P	P	N	N
Jacksonville	N	P	N	N	N	P	P	P	P	N	N	N	P	N
Key West	P	P	P	P	N	P	P	P	N	P	P	P	N	P
Lakeland	N	P	N	N	N	P	P	P	P	N	P	N	N	P
Miami	N	N	N	N	N	N	P	P	P	N	P	N	N	P
Orlando	N	P	P	P	N	P	P	P	P	P	P	P	P	P
Pensacola	N	P	N	N	P	N	P	P	N	N	N	N	N	P
Tallahassee	P	P	P	P	P	P	P	P	N	N	N	P	P	P
Tampa	P	P	P	P	N	P	P	P	P	N	N	N	P	P
West Palm Beach	P	P	P	N	P	P	P	P	P	P	P	P	N	P
GEORGIA														
Athens	P	P	P	P	P	P	P	P	P	P	P	N	P	P
Atlanta	P	N	P	P	P	P	P	P	P	N	P	N	N	P
Augusta	N	N	P	P	P	P	P	P	N	P	P	P	P	P
Columbus	P	N	P	P	P	P	P	P	P	P	P	P	P	P
Macon	N	N	P	P	P	P	P	P	P	P	P	P	P	P
Rome	P	N	P	P	P	N	N	N	P	N	N	N	N	N
Savannah	P	P	N	P	N	P	P	P	N	P	N	P	N	P
Thomasville	N	P	P	N	N	P	P	P	N	N	N	N	P	P
MISSISSIPPI														
Meridian	P	N	P	P	P	N	P	P	N	N	N	N	N	N
SOUTH CAROLINA														
Charleston	P	N	N	P	N	P	P	N	P	P	N	N	N	N
Columbia	P	N	P	P	P	N	P	P	P	P	P	N	N	P
Greenville	N	N	N	P	P	P	P	P	P	P	N	P	P	P
TENNESSEE														
Chattanooga	P	N	P	P	P	P	P	P	P	P	P	N	P	P
Knoxville	P	P	P	N	P	P	P	P	P	P	N	P	P	P
Nashville	P	N	P	P	P	P	P	P	P	P	N	P	P	N

+P=Poisson, N=Negative Binomial
*T=Thunderstorm Days; H=Hail Days

Georgia, the Poisson model is also appropriate during spring months. In Florida, however, where the frequency of thunderstorms is greater than either Alabama or Georgia, the selection is mixed; that is, no consistent pattern on a specific model selection is apparent. Comparisons of the Poisson and negative binomial distribution are illustrated in the Appendix for annual thunderstorm days at Lakeland, Florida; Atlanta, Georgia; and Mobile, Alabama.

Distribution of annual hail days in the Southeastern States generally favored the Poisson distribution. For annual thunderstorm days, the program selection generally favored the negative binomial distribution in Florida, South Carolina, Mississippi, and the Poisson distribution in Alabama, Georgia, and Tennessee.

In spite of the high occurrence of thunderstorms in the Southeast, the number of hail days is small. As Table 3 indicates, the highest number of hail days is found in the more northern latitudes of the study area, e.g., northern Alabama, northern Georgia, and Tennessee. This is reasonable since this is where frontal movement is strongest in the area during the spring and fall.

As expected, the greatest variability of thunderstorm days was found during the summer months when the occurrence was greatest, see Table 4. Of the states considered, Florida possessed the greatest variability while the smallest variability was found in the northern sector of the study area, including Tennessee, northern Georgia, and northern South Carolina.

Probability Tables

In tables 5 through 35 are listed the cumulative probability thunderstorm days for the indicated number of days in a month. The tables are entered alphabetically beginning with Anniston, Alabama through West Palm Beach, Florida. Probabilities for annual hail days are also indicated in the tables. The probability values for selected number of thunderstorm or hail days is illustrated as follows.

At Anniston, Alabama, Table 5, for example, the probability of receiving more than 5 thunderstorm days in June is 99 percent (1.00 minus .01). This also implies that Anniston is virtually assured of getting at least 4 days each year with thunderstorms in June. The probability of more than 9 thunderstorm days is 81 percent (1.00 minus 0.19). The average number of thunderstorm or hail days can also be determined from the tables by finding the

TABLE 3. MONTHLY AND ANNUAL MEANS FOR THUNDERSTORM AND HAIL DAYS IN THE SOUTHEAST UNITED STATES

	J	F	M	A	M	J	J	A	S	O	N	D	T*	H*
Alabama														
Anniston	0.9	2.3	4.2	5.2	7.7	12.6	14.8	12.2	6.6	1.6	1.0	1.2	70.2	1.4
Birmingham	1.3	2.3	4.3	5.1	6.6	8.6	11.8	9.1	3.4	1.2	1.7	1.2	56.6	2.0
Mobile	1.7	2.0	4.6	4.7	6.9	11.6	17.1	14.1	7.0	2.0	2.0	2.1	76.0	0.5
Montgomery	1.4	1.9	4.1	5.4	6.5	9.0	12.1	8.7	3.4	1.4	1.7	1.8	57.4	0.6
Florida														
Apalachicola	1.2	2.3	3.7	3.1	4.8	9.2	15.7	14.7	8.3	1.7	1.6	1.6	68.4	0.2
Daytona Beach	1.0	1.9	2.7	3.4	8.1	12.7	17.1	15.5	8.1	3.3	1.1	0.9	75.5	0.3
Fort Myers	0.7	1.6	2.4	3.5	8.1	15.7	23.3	21.8	15.1	4.5	1.1	0.7	98.3	0.3
Jacksonville	0.7	1.0	2.7	3.5	6.2	9.9	14.9	12.3	5.6	1.5	0.6	0.9	60.0	1.0
Key West	0.8	1.3	1.7	2.0	4.6	8.7	11.1	12.2	10.2	4.0	0.8	0.9	58.2	0.2
Lakeland	1.1	1.6	3.5	3.8	8.4	17.0	22.6	20.8	12.1	3.0	1.2	1.2	96.3	0.6
Miami	0.6	0.7	1.4	3.1	6.3	11.6	14.0	14.3	10.2	4.3	0.8	0.7	67.6	0.4
Orlando	1.0	1.7	2.2	3.2	7.2	12.9	18.2	15.9	8.2	2.4	0.9	0.8	74.4	0.9
Pensacola	1.7	1.7	3.4	3.9	4.8	8.9	12.9	12.6	7.7	1.9	1.5	1.7	64.0	0.2
Tallahassee	1.4	1.9	4.0	4.5	7.9	13.6	19.5	16.2	7.5	2.0	1.4	1.2	81.2	0.5
Tampa	0.8	1.4	2.5	3.0	6.2	14.5	22.0	20.4	12.1	2.6	1.3	1.1	87.5	0.5
West Palm Beach	0.6	1.5	2.2	3.4	6.7	13.1	15.1	16.7	11.9	4.7	1.1	0.6	75.7	0.5
Georgia														
Athens	1.1	1.3	3.1	4.8	5.7	8.9	12.8	9.0	2.7	0.8	1.1	0.6	52.0	0.7
Atlanta	0.9	1.6	3.3	4.2	5.6	8.3	10.7	7.8	2.5	1.1	1.0	0.7	47.7	0.9
Augusta	0.7	0.9	2.8	4.4	6.1	9.8	13.1	9.9	3.4	1.0	1.2	0.5	53.8	0.6
Columbus	1.1	1.8	3.2	4.7	5.8	9.1	13.7	9.5	3.4	1.1	0.9	1.3	55.3	0.6
Macon	1.1	1.5	3.7	4.7	6.2	9.1	13.7	10.0	3.6	0.8	1.0	0.7	56.1	1.3
Rome	1.1	1.6	3.2	6.1	6.1	8.7	11.9	8.6	4.1	2.0	1.3	0.5	53.4	0.9
Savannah	0.7	0.8	3.1	4.0	7.3	10.6	15.3	11.9	5.5	1.4	0.6	0.5	61.9	1.0
Thomasville	1.1	1.8	3.6	5.1	7.4	12.7	16.2	14.3	6.9	1.7	1.0	0.9	72.9	0.5
Mississippi														
Meridian	1.4	2.5	4.2	5.4	6.2	7.7	12.0	8.8	4.0	1.4	1.8	2.0	57.7	0.5
South Carolina														
Charleston	0.6	0.9	2.1	3.0	6.6	10.2	14.2	11.4	5.1	1.0	0.7	0.3	56.0	0.4
Columbia	0.5	1.4	3.4	3.6	5.3	8.9	12.8	9.8	3.6	1.2	0.6	0.3	49.9	0.9
Greenville	0.7	1.0	2.5	3.4	5.7	8.7	11.3	7.9	2.8	1.3	0.6	0.4	46.2	1.3
Tennessee														
Chattanooga	1.4	1.9	3.5	4.8	7.2	9.5	11.7	9.0	3.6	1.4	1.1	0.6	56.0	1.2
Knoxville	0.9	1.2	3.0	4.4	6.3	8.4	10.2	7.2	3.0	1.2	0.9	0.4	47.2	1.8
Nashville	1.6	1.8	3.8	5.6	7.6	8.4	10.5	7.9	3.5	1.4	1.4	1.1	54.7	2.2

T* = Annual thunderstorm days.
H* = Annual hail days.

TABLE 4. MONTHLY AND ANNUAL VARIANCES FOR THUNDERSTORM AND HAIL DAYS IN THE SOUTHEAST UNITED STATES

	J	F	M	A	M	J	J	A	S	O	N	D	T*	H*
Alabama														
Anniston	0.8	3.5	8.0	7.2	9.6	9.2	10.3	15.2	11.3	2.6	1.0	2.6	281.2	1.3
Birmingham	1.3	3.9	4.6	6.5	6.2	12.4	17.3	11.6	3.4	0.8	0.9	1.4	66.3	2.2
Mobile	2.2	2.5	6.7	6.2	7.9	11.7	19.9	11.4	16.1	2.9	3.5	2.5	96.4	0.3
Montgomery	2.3	4.2	4.2	5.2	7.6	4.6	9.9	9.3	4.3	1.7	2.0	2.6	52.6	1.5
Florida														
Apalachicola	2.0	2.3	4.7	4.0	6.2	16.8	16.4	16.0	16.8	2.4	2.0	2.1	173.6	0.2
Daytona Beach	1.0	1.7	4.0	4.6	24.0	18.8	18.0	10.4	13.1	8.5	0.8	1.9	153.0	0.3
Fort Myers	1.1	2.0	5.6	11.6	14.3	12.2	19.4	15.9	14.4	13.7	0.9	0.8	165.3	0.5
Jacksonville	1.1	0.7	5.3	5.2	9.7	14.6	14.9	13.6	6.6	3.0	0.9	1.9	72.4	1.5
Key West	0.9	1.7	2.2	2.0	9.6	12.1	10.3	12.4	17.7	5.3	1.0	1.1	117.1	0.2
Lakeland	1.7	2.0	5.2	6.7	15.2	14.7	13.4	14.6	13.0	5.4	1.4	2.2	187.0	0.7
Miami	0.9	1.2	2.4	4.8	10.1	18.5	8.5	13.8	14.7	8.7	1.1	1.1	126.2	0.4
Orlando	1.7	1.0	3.4	3.5	17.6	8.6	10.9	10.5	11.4	3.7	1.1	0.6	69.6	0.6
Pensacola	2.8	2.0	7.1	7.4	6.4	15.3	16.4	13.0	17.1	3.6	3.3	2.8	123.1	0.3
Tallahassee	1.4	1.7	4.9	4.4	11.6	13.4	12.5	14.0	12.6	3.8	2.4	1.8	69.6	0.4
Tampa	0.8	1.5	3.0	4.2	16.1	12.8	14.8	7.8	12.7	5.2	2.2	1.8	110.9	0.3
West Palm Beach	0.5	1.3	2.9	5.7	7.7	12.1	13.6	11.6	13.6	4.0	0.8	0.8	136.6	0.7
Georgia														
Athens	1.2	1.3	3.0	3.3	4.9	10.1	9.2	7.0	2.0	0.9	1.6	1.0	39.7	0.6
Atlanta	1.2	3.3	3.4	3.7	7.5	11.8	13.0	9.6	3.0	2.5	1.0	1.1	95.3	0.7
Augusta	1.7	1.9	3.3	4.4	6.5	10.8	10.5	7.9	5.3	1.5	1.7	0.6	48.4	0.8
Columbus	1.5	4.1	2.6	3.1	8.0	8.3	14.6	9.1	4.7	1.2	0.7	1.8	51.0	0.6
Macon	2.3	3.6	4.8	5.1	8.3	8.1	10.6	8.2	4.5	0.8	1.3	0.8	78.7	1.6
Rome	1.5	2.8	4.1	3.6	5.4	14.4	23.9	20.9	5.3	3.8	2.5	0.9	263.4	1.5
Savannah	0.8	0.9	4.9	4.3	13.6	12.5	19.0	9.9	9.4	1.9	1.7	0.4	102.1	0.9
Thomasville	1.9	1.7	2.1	8.2	12.5	11.2	17.9	15.1	13.7	3.2	2.5	1.5	90.3	0.6
Mississippi														
Meridian	0.9	4.3	6.0	5.6	8.1	11.9	15.7	9.4	6.1	2.2	3.6	3.0	113.3	0.7
South Carolina														
Charleston	0.7	1.4	3.1	2.9	14.8	12.7	17.6	16.8	6.0	1.3	1.2	0.5	141.3	0.7
Columbia	0.5	2.9	2.2	3.1	5.2	16.6	16.2	11.8	3.5	1.6	0.8	0.5	207.1	0.9
Greenville	1.2	1.8	3.6	3.4	5.2	9.6	14.6	8.1	2.5	1.6	0.9	0.5	65.3	1.3
Tennessee														
Chattanooga	1.2	3.0	4.0	4.5	6.5	11.5	11.7	11.3	4.9	1.9	1.6	1.0	67.0	0.8
Knoxville	0.8	1.6	3.5	4.0	9.8	10.7	14.2	7.1	3.2	1.8	1.6	0.4	51.3	1.6
Nashville	1.8	3.4	5.6	4.7	4.8	9.9	5.8	7.5	3.6	1.5	2.5	1.1	35.6	4.7

T* = Annual thunderstorm days.
H* = Annual hail days.

number of days that corresponds to 50 percent probability. In the case of Anniston in June, this value is approximately 12 days. The chance of more than 15 thunderstorm days in this month is only 20 percent (1.00 minus 0.80). Another way of interpreting the table is given in the example that follows: the probability of receiving 9 or less (at least 9) thunderstorm days in June is 0.19; for exactly 9 days, it is .07 (.19 minus .12).

One of the characteristics of the distributions considered in this study is the slow covergence of the values about 95 to 100 percent (or 1.00). For practical reasons, a decision was made to round the probability to 1.00 whenever the maximum number of days in a month was reached. This was necessary at two locations, Lakeland and Tampa for the month of July only. From these tables, graphs of monthly cumulative probabilities can also be drawn to facilitate interpretation. An example is shown for August at Lakeland, Florida, Figure 3. It is easy to see that the probability of 20 or less thunderstorm days at Lakeland in August is

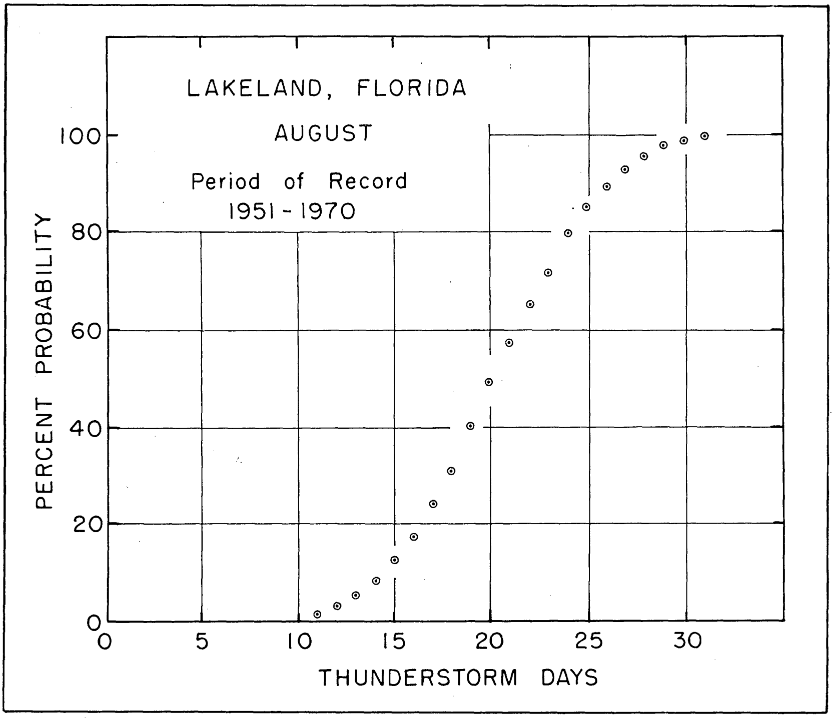

FIG. 3. Sample plot of thunderstorm days for the month of August at Lakeland, Florida.

approximately 50 percent. The chance of more than 20 is 100 minus 50 or 50 percent.

Atlas

Figures 4 through 23 provide the selected probability levels, 10, 25, 50, 75, and 90 percent for thunderstorm days during January, April, July, and October. Figure 24 is the mean annual

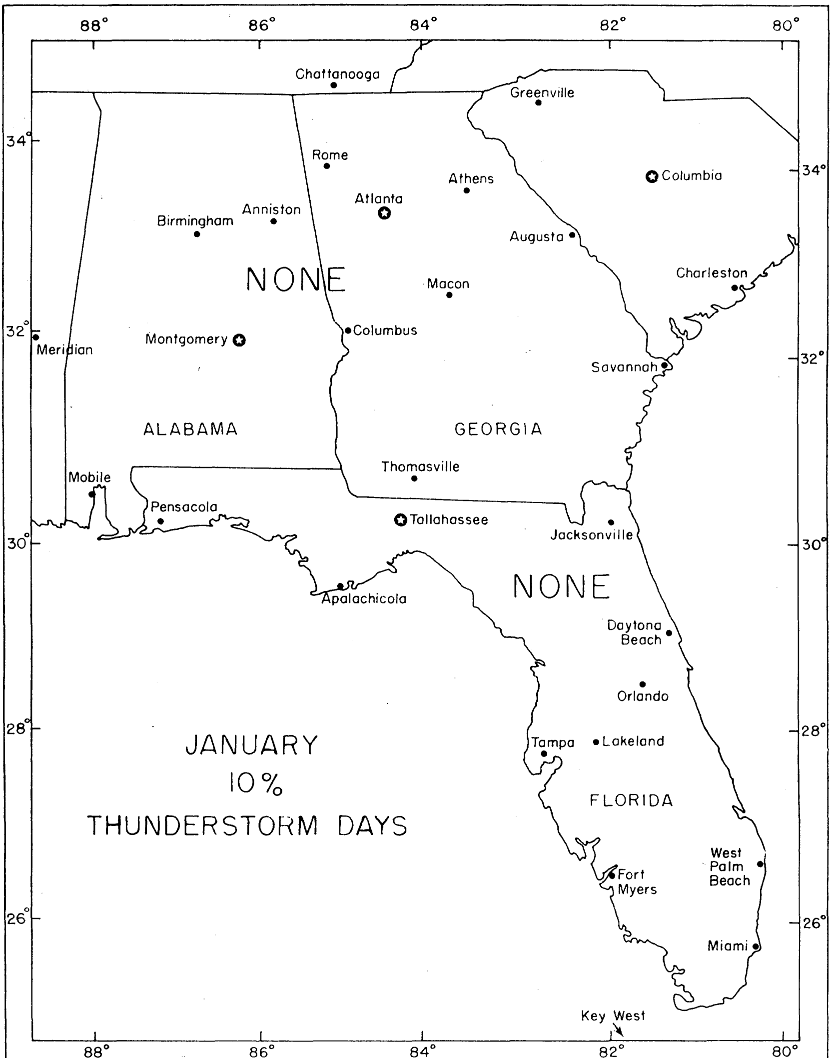

FIG. 4. Ten percent thunderstorm days in January.

thunderstorm days while Figure 25 presents the mean annual hail days. These maps were analyzed from the output listed in the tables 5 through 35. The lines are drawn from results of a mixed distribution, the Poisson and negative binomial. However, the selected model best fits the observed data and the results are, for practical consideration, considered adequate. Distinct seasonal

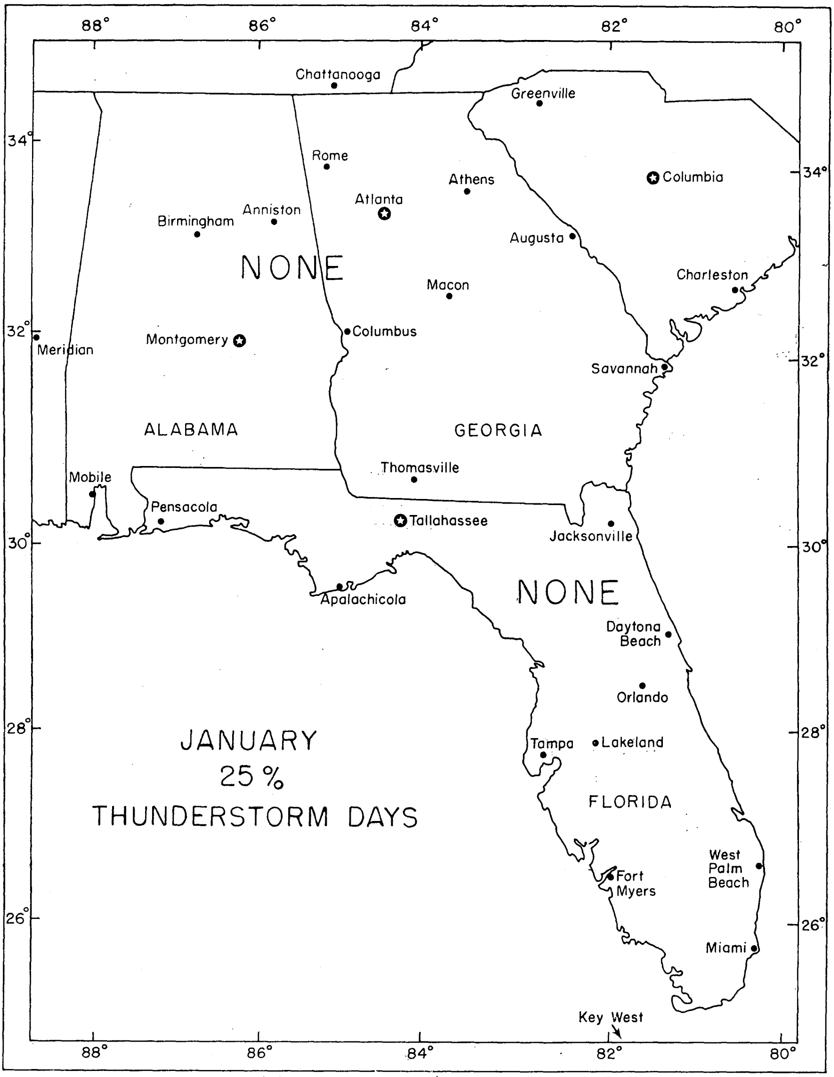

FIG. 5. Twenty-five percent thunderstorm days in January.

patterns of maximum and minimum areas are discernible from the maps. Orographic effects, in addition to ocean-land thermal differences, are also evident. Movement of fronts no doubt contribute to the distribution of thunderstorm days.

The probability level shown on each figure is the chance of receiving at least the indicated number of thunderstorm days.

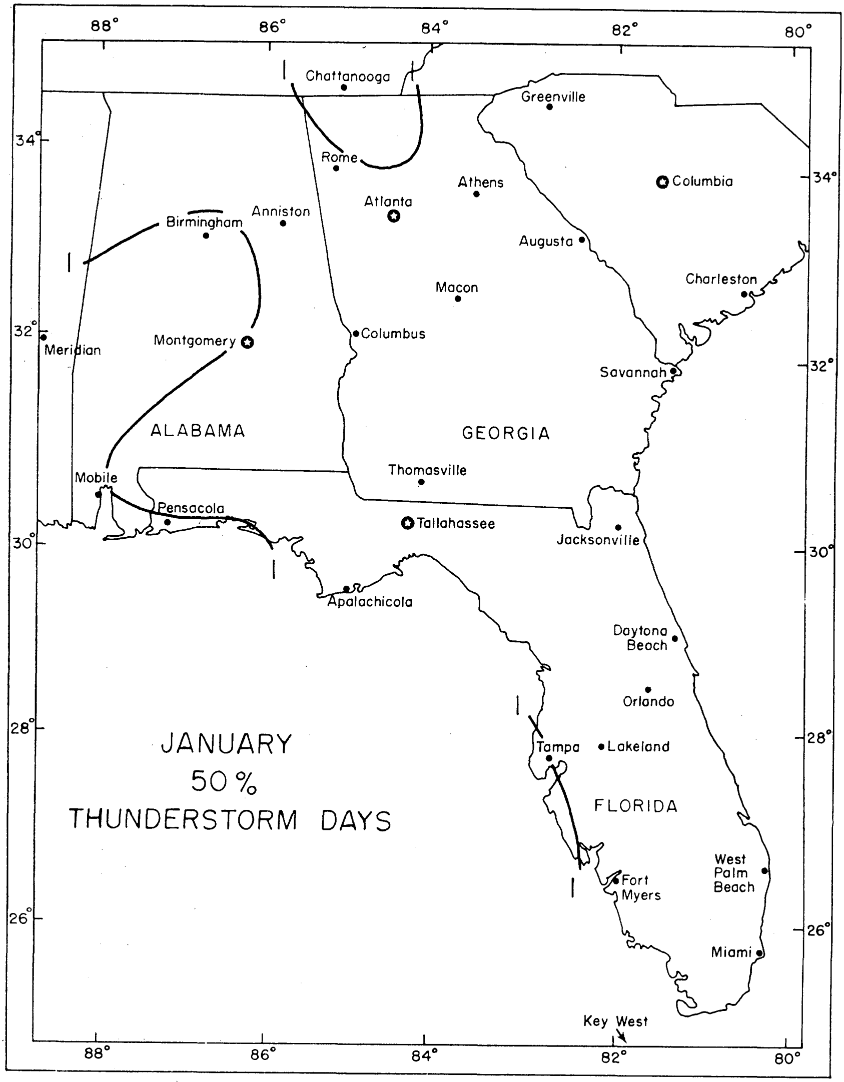

FIG. 6. Fifty percent thunderstorm days in January.

For example, in January, Figure 8, the chance of Montgomery, Alabama receiving 3 or less thunderstorm days is 90 percent. Another way to interpret this is there is only a 10 percent chance of having more than 3 days in January with a thunderstorm. Pockets of maximum and minimum areas in Figure 8 are associated primarily with frontal passages in Alabama and Georgia. In Florida,

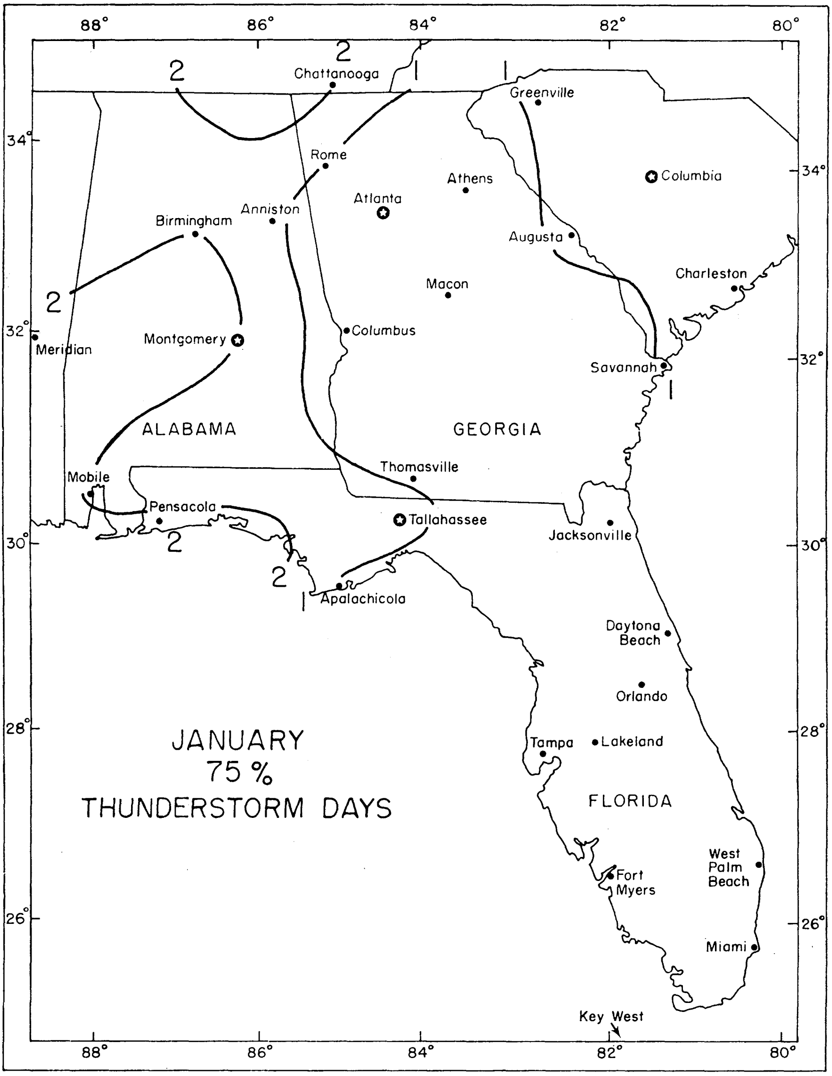

FIG. 7. Seventy-five percent thunderstorm days in January.

the maximum area of thunderstorms is situated on the Gulf of Mexico side while the minimum area of thunderstorm days is in the southeastern section of Florida. As a practical application, a vacationer might do better in terms of avoiding a thundershower if he visited West Palm Beach rather than Tampa.

In April three areas of maximum thunderstorm days are shown; one over the southeastern Alabama-southwestern Georgia corner,

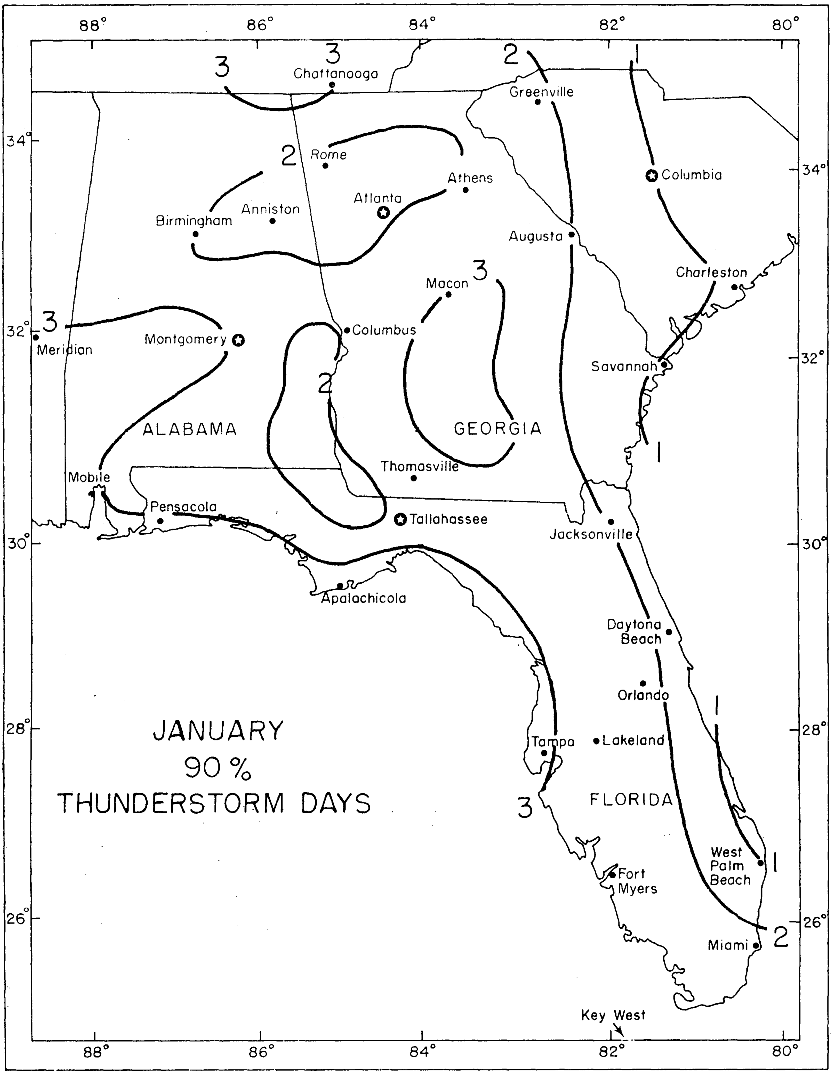

FIG. 8. Ninety percent thunderstorm days in January.

over the Anniston-Rome area and a third over southern Florida, Figure 13. A minimum area is apparently indicated on the lee side of the mountains of northwest Georgia. The maximum over Anniston-Rome area may be the combined influence of orographic and frontal association. The maximum in southwestern Georgia is the influence of frontal activity and associated squall lines that

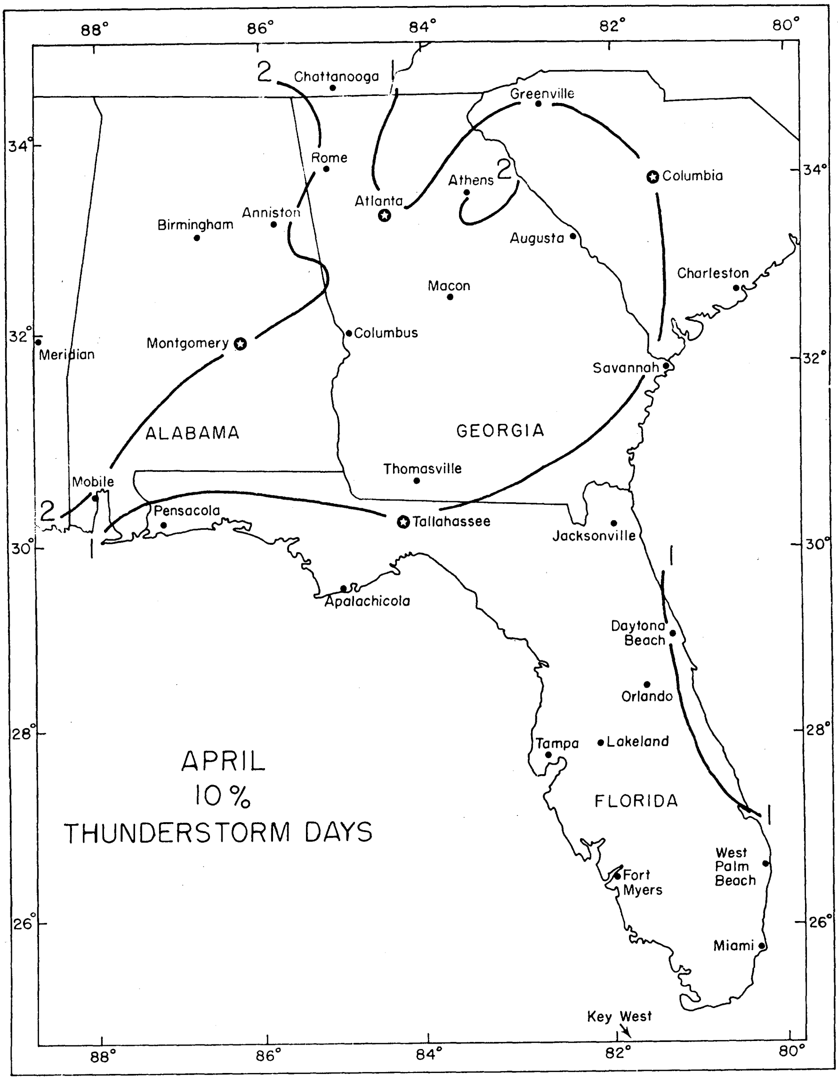

FIG. 9. Ten percent thunderstorm days in April.

are common in spring. The map for April also suggests that the farmers in southwestern Georgia stand a slightly greater risk of early crop damage by thunderstorms than the farmers in eastern and southeastern Georgia.

In July the area of maximum thunderstorm days shifts westward over southern Florida, Figure 18, so that western Florida

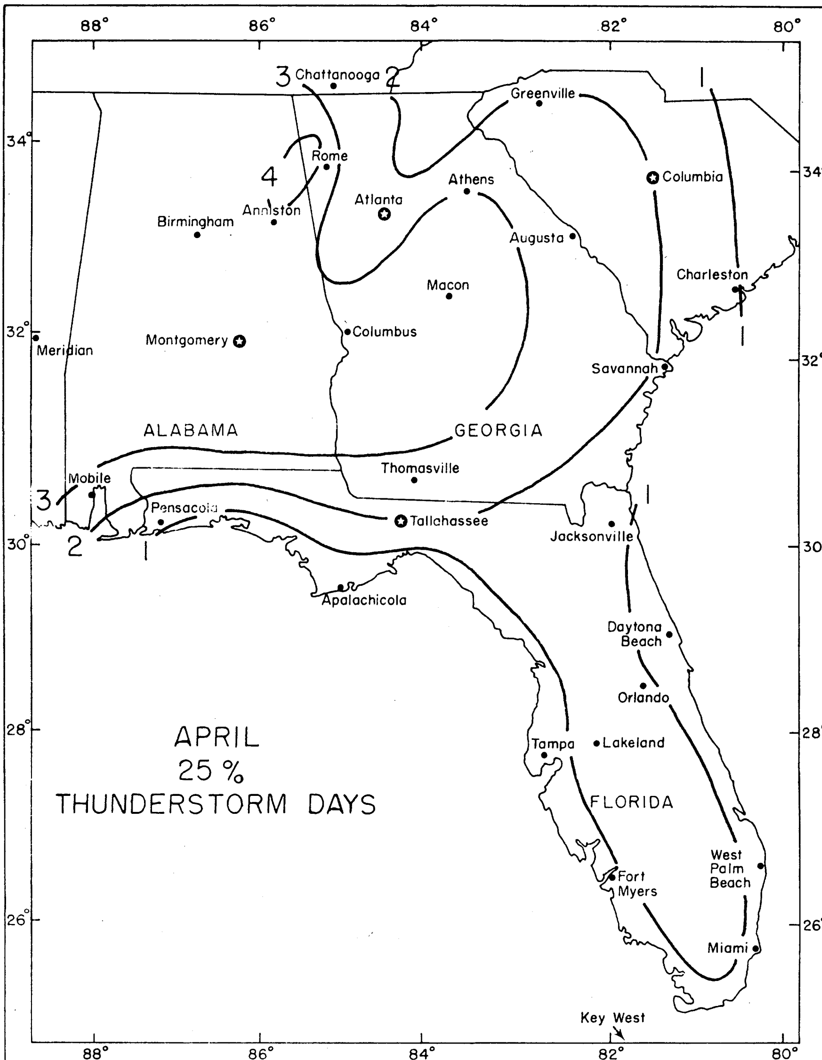

FIG. 10. Twenty-five percent thunderstorm days in April.

receives more days with thunderstorms than eastern Florida over the same period. The maximum in the area of Anniston-Rome is still evident in July when thunderstorms are primarily the air mass type. Summer rainfall in the Southeastern States is very important to agriculture for crops during critical stages of growth and development. In Florida, over half of the annual rainfall

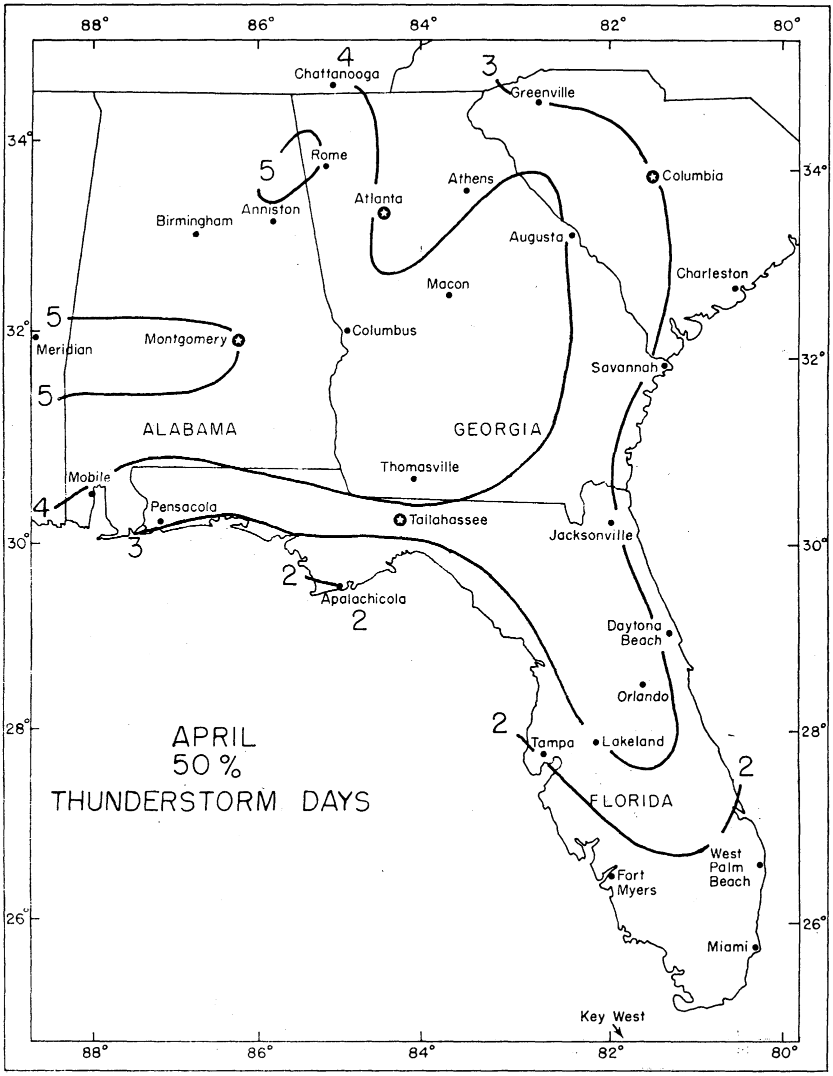

FIG. 11. Fifty percent thunderstorm days in April.

comes during the 4-month peak thunderstorm period, June through September, Bradley (2).

In October, a change in the thermal regime and frontal tracks brings the maximum thunderstorm area in the mountainous regions of Georgia and Alabama. In Florida, the maximum area moves to the southern tip of that state.

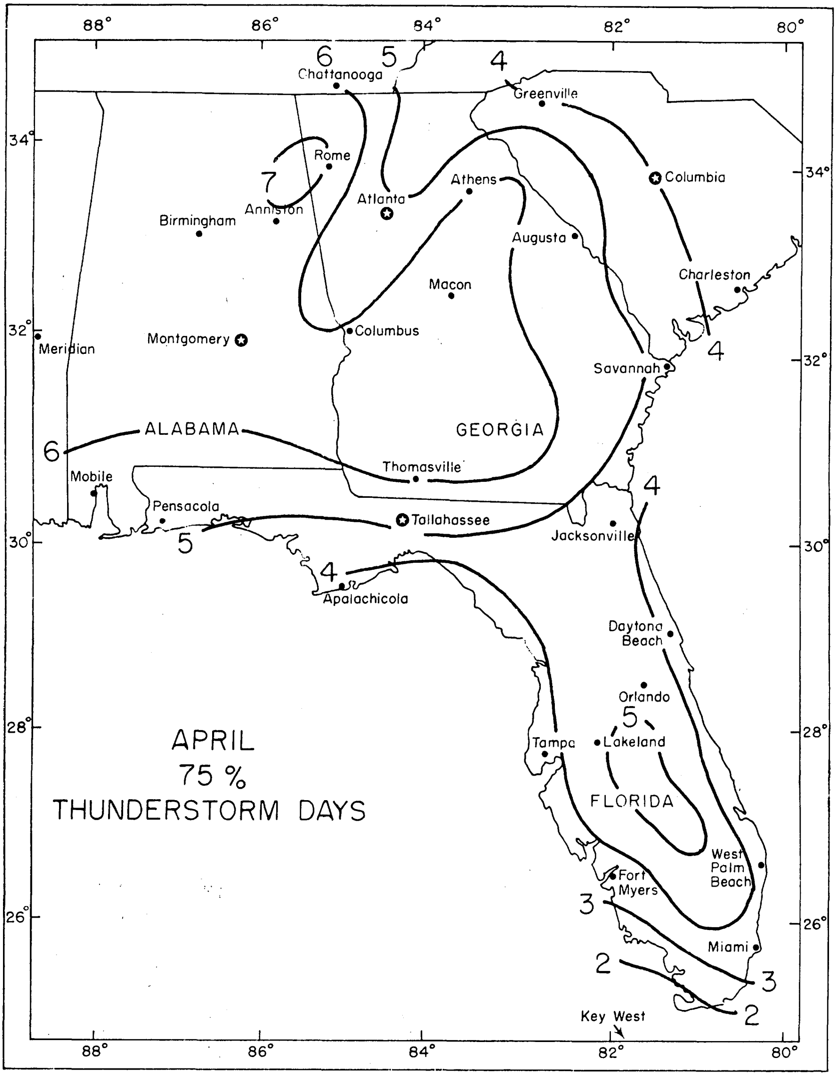

FIG. 12. Seventy-five percent thunderstorm days in April.

The Atlas is as complete as the data allowed; however, data-sparse regions do exist (e.g., the non-coastal areas of Florida.) Any revisions to the Atlas should include an intensive effort to fill in these data-sparse areas.

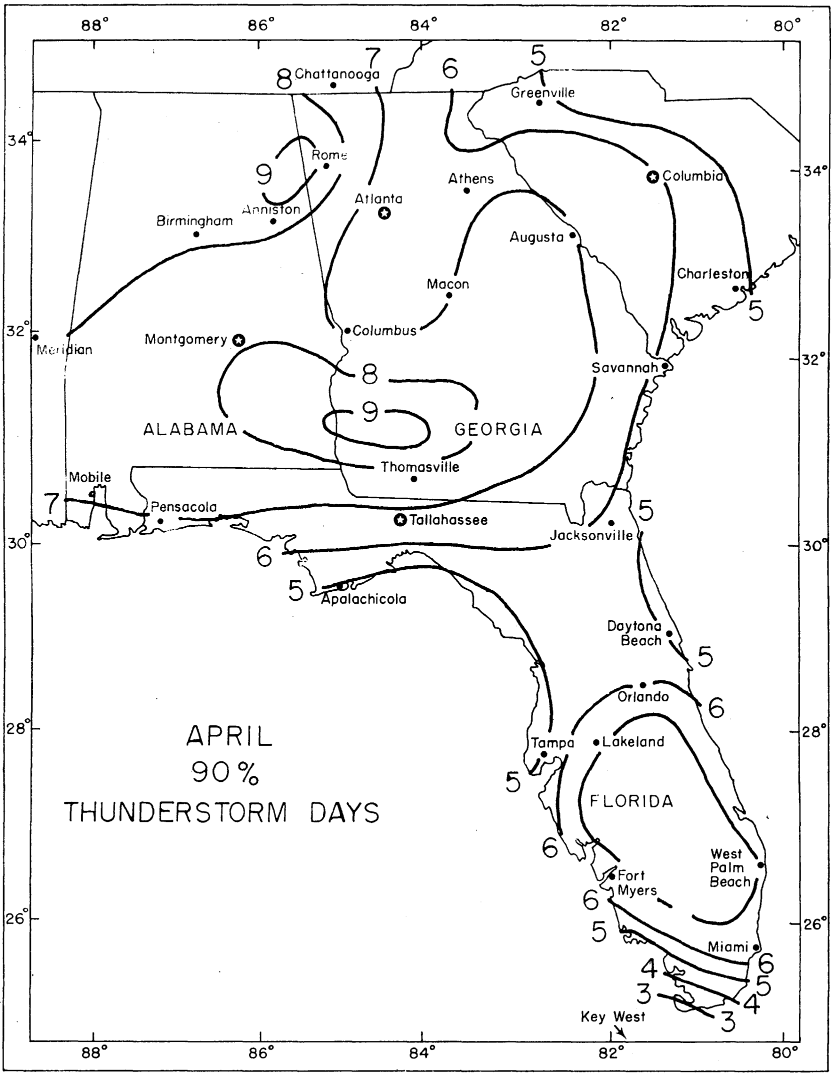

FIG. 13. Ninety percent thunderstorm days in April.

ACKNOWLEDGMENT

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TABLE 5. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT ANNISTON, ALABAMA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.40	0.10	0.05	0.01	0.00	0.00	0.00	0.00	0.01	0.29	0.37	0.48	0.24
1	0.77	0.33	0.16	0.04	0.00	0.00	0.00	0.00	0.03	0.57	0.74	0.72	0.58
2	0.93	0.59	0.31	0.11	0.02	0.00	0.00	0.00	0.09	0.76	0.92	0.84	0.82
3	0.99	0.80	0.47	0.24	0.05	0.00	0.00	0.00	0.18	0.87	0.98	0.91	0.94
4	1.00	0.91	0.61	0.41	0.12	0.00	0.00	0.01	0.29	0.94	1.00	0.95	0.98
5		0.97	0.73	0.59	0.22	0.01	0.00	0.02	0.41	0.97		0.97	1.00
6		0.99	0.82	0.74	0.35	0.03	0.01	0.04	0.54	0.98		0.98	
7		1.00	0.88	0.85	0.50	0.07	0.02	0.08	0.65	0.99		0.99	
8			0.92	0.92	0.64	0.12	0.04	0.14	0.74	1.00		1.00	
9			0.95	0.96	0.76	0.19	0.08	0.23	0.82				
10			0.97	0.98	0.85	0.29	0.13	0.33	0.87				
11			0.98	0.99	0.91	0.40	0.20	0.43	0.92				
12			0.99	1.00	0.95	0.51	0.29	0.55	0.95				
13			0.99		0.97	0.62	0.39	0.66	0.97				
14			1.00		0.99	0.72	0.49	0.75	0.98				
15					0.99	0.80	0.59	0.83	0.99				
16					1.00	0.86	0.69	0.89	0.99				
17						0.91	0.77	0.93	1.00				
18						0.94	0.84	0.96					
19						0.97	0.89	0.98					
20						0.98	0.93	0.99					
21						0.99	0.95	0.99					
22						0.99	0.97	1.00					
23						1.00	0.98						
24							0.99						
25							0.99						
26							1.00						

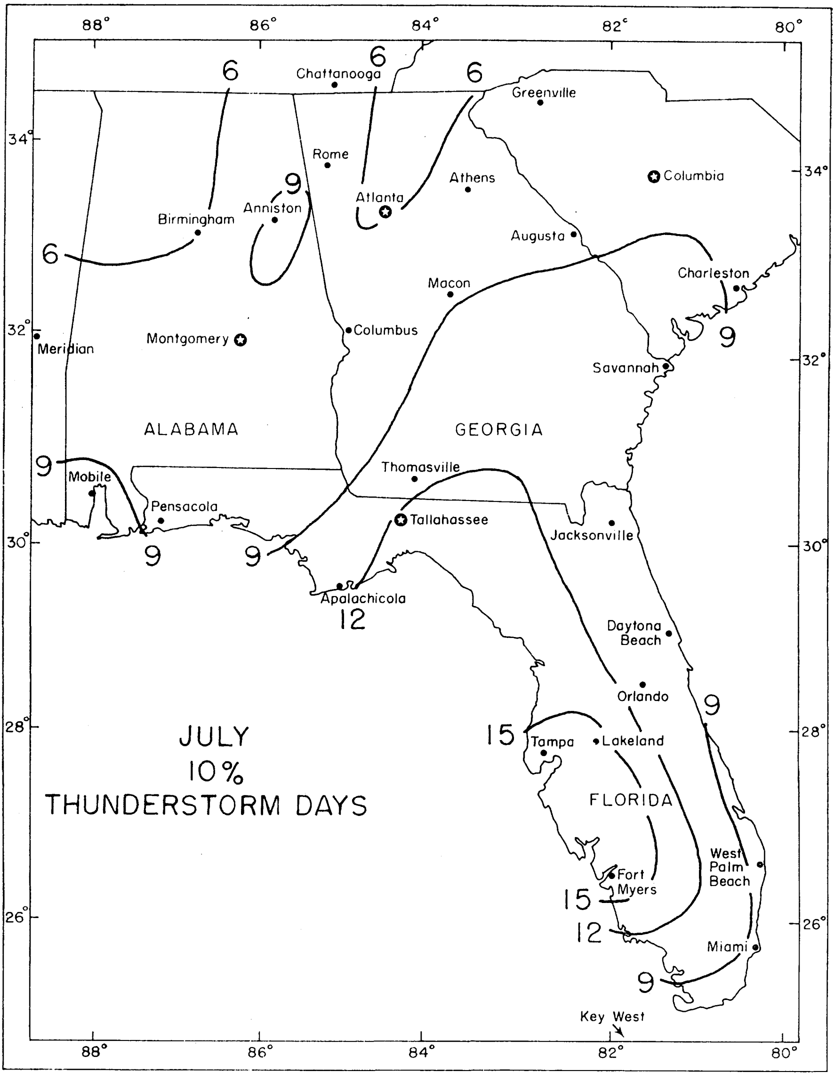


FIG. 14. Ten percent thunderstorm days in July.

TABLE 6. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT APALACHICOLA, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.40	0.10	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.18	0.20	0.21	0.82
1	0.68	0.33	0.11	0.18	0.04	0.01	0.00	0.00	0.02	0.49	0.51	0.54	0.98
2	0.84	0.60	0.28	0.40	0.14	0.02	0.00	0.00	0.06	0.76	0.77	0.79	1.00
3	0.92	0.80	0.49	0.62	0.29	0.06	0.00	0.00	0.12	0.91	0.92	0.93	
4	0.96	0.92	0.68	0.80	0.48	0.11	0.00	0.00	0.20	0.97	0.97	0.98	
5	0.98	0.97	0.83	0.91	0.65	0.18	0.00	0.00	0.29	0.99	0.99	0.99	
6	0.99	0.99	0.92	0.96	0.79	0.27	0.00	0.01	0.39	1.00	1.00	1.00	
7	1.00	1.00	0.96	0.99	0.89	0.37	0.01	0.02	0.48				
8			0.99	1.00	0.94	0.47	0.03	0.04	0.58				
9			0.99		0.97	0.57	0.05	0.08	0.66				
10			1.00		0.99	0.66	0.09	0.14	0.73				
11					1.00	0.74	0.14	0.21	0.79				
12						0.80	0.21	0.30	0.84				
13						0.85	0.30	0.40	0.88				
14						0.89	0.39	0.50	0.91				
15						0.92	0.49	0.60	0.94				
16						0.95	0.59	0.70	0.95				
17						0.96	0.68	0.78	0.97				
18						0.98	0.76	0.84	0.98				
19						0.98	0.83	0.89	0.98				
20						0.99	0.88	0.93	0.99				
21						0.99	0.92	0.96	0.99				
22						1.00	0.95	0.97	0.99				
23							0.97	0.98	1.00				
24							0.98	0.99					
25							0.99	1.00					
26							0.99						
27							1.00						

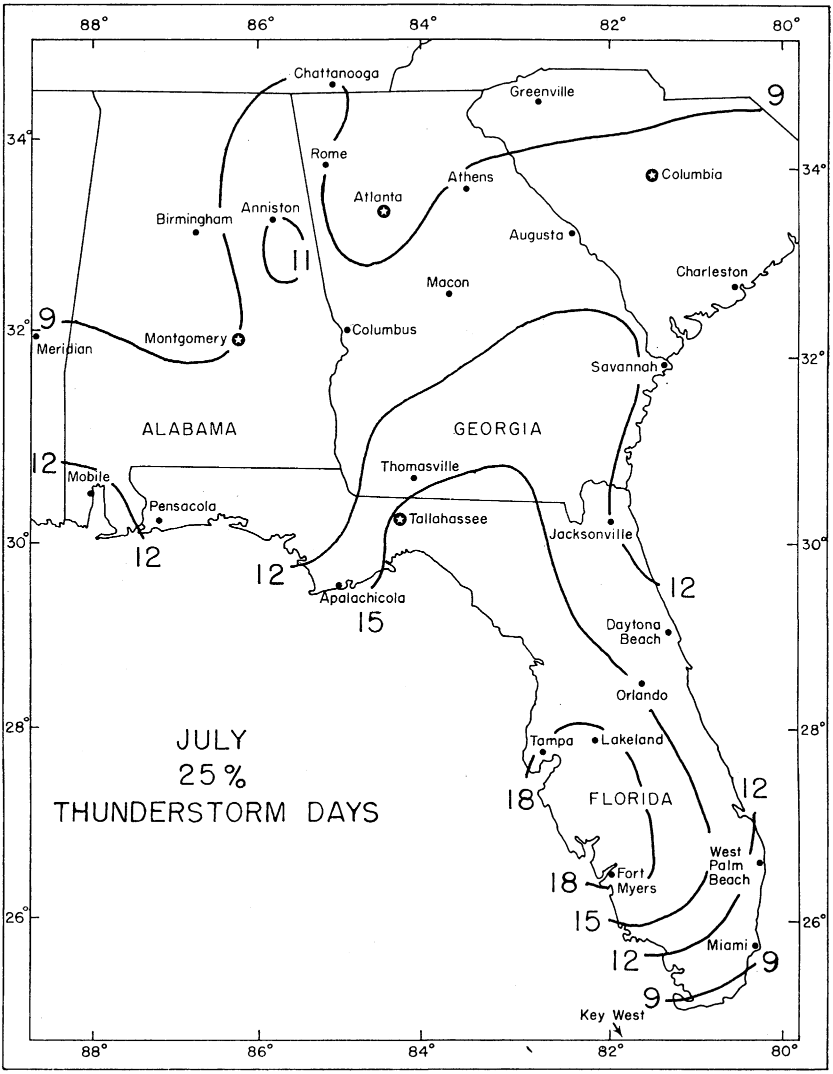


FIG. 15. Twenty-five percent thunderstorm days in July.

TABLE 7. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT ATHENS, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.29	0.27	0.05	0.01	0.00	0.00	0.00	0.00	0.07	0.45	0.33	0.71	0.50
1	0.64	0.63	0.19	0.05	0.02	0.00	0.00	0.00	0.25	0.81	0.70	0.87	0.90
2	0.87	0.86	0.41	0.14	0.08	0.01	0.00	0.01	0.49	0.95	0.90	0.94	0.94
3	0.96	0.96	0.64	0.29	0.19	0.02	0.00	0.02	0.71	0.99	0.97	0.97	0.99
4	0.99	0.99	0.81	0.48	0.33	0.06	0.00	0.06	0.86	1.00	0.99	0.98	1.00
5	1.00	1.00	0.91	0.65	0.50	0.13	0.01	0.12	0.94		1.00	0.99	
6			0.96	0.79	0.66	0.22	0.03	0.21	0.98			1.00	
7			0.99	0.89	0.79	0.34	0.06	0.33	0.99				
8			1.00	0.94	0.88	0.48	0.11	0.46	1.00				
9				0.97	0.94	0.61	0.18	0.59					
10				0.99	0.97	0.72	0.27	0.71					
11				1.00	0.99	0.82	0.38	0.81					
12					0.99	0.89	0.49	0.88					
13					1.00	0.93	0.60	0.93					
14						0.96	0.70	0.96					
15						0.98	0.79	0.98					
16						0.99	0.85	0.99					
17						1.00	0.90	0.99					
18							0.94	1.00					
19							0.96						
20							0.98						
21							0.99						
22							0.99						
23							1.00						

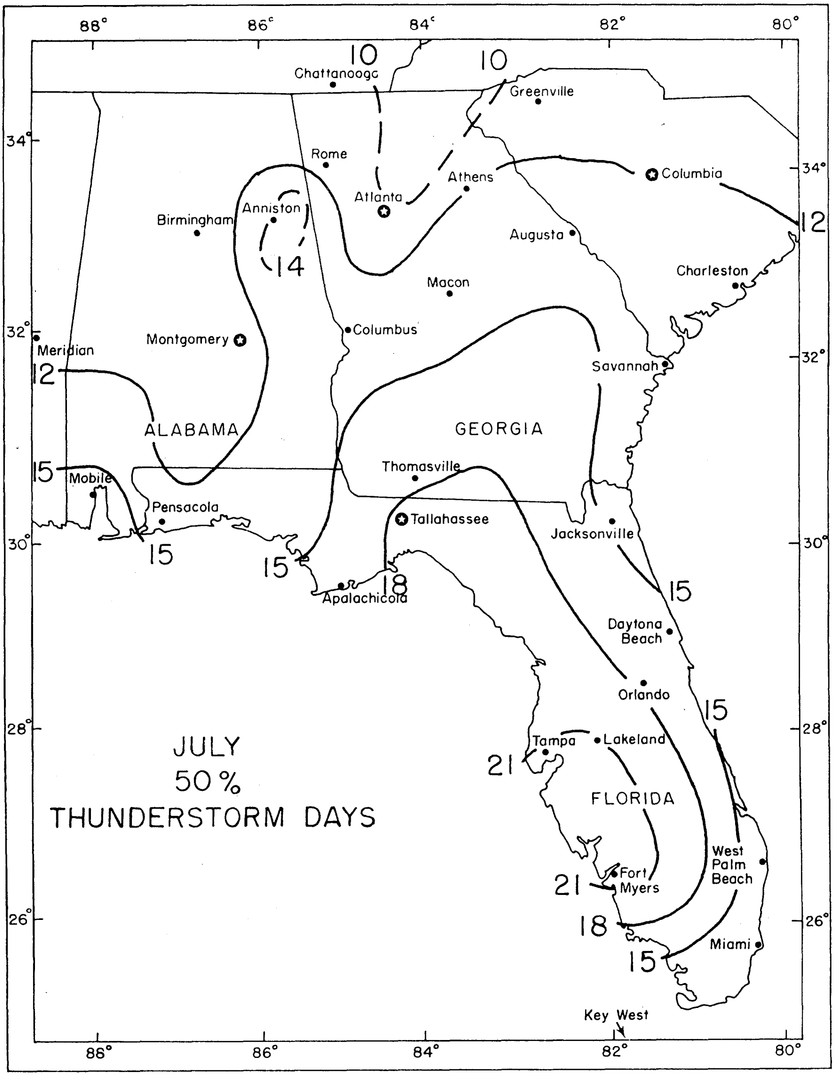


FIG. 16. Fifty percent thunderstorm days in July.

TABLE 8. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT ATLANTA, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.41	0.32	0.04	0.02	0.00	0.00	0.00	0.00	0.08	0.52	0.37	0.66	0.39
1	0.77	0.59	0.16	0.08	0.02	0.00	0.00	0.00	0.28	0.73	0.74	0.84	0.76
2	0.94	0.76	0.36	0.21	0.08	0.01	0.00	0.02	0.54	0.85	0.92	0.92	0.93
3	0.99	0.86	0.58	0.40	0.19	0.03	0.01	0.05	0.75	0.91	0.98	0.96	0.98
4	1.00	0.92	0.76	0.60	0.34	0.08	0.02	0.11	0.89	0.95	1.00	0.98	1.00
5		0.96	0.88	0.76	0.51	0.17	0.04	0.21	0.96	0.97		0.99	
6		0.98	0.95	0.87	0.67	0.28	0.09	0.34	0.98	0.98		0.99	
7		0.99	0.98	0.94	0.80	0.41	0.16	0.49	1.00	0.99		1.00	
8		0.99	0.99	0.97	0.89	0.55	0.26	0.63		0.99			
9		1.00	1.00	0.99	0.94	0.68	0.37	0.75		1.00			
10				1.00	0.97	0.79	0.49	0.84					
11					0.99	0.87	0.61	0.90					
12					0.99	0.92	0.72	0.95					
13					1.00	0.96	0.81	0.97					
14						0.98	0.87	0.99					
15						0.99	0.92	0.99					
16						0.99	0.95	1.00					
17						1.00	0.97						
18							0.99						
19							0.99						
20							1.00						

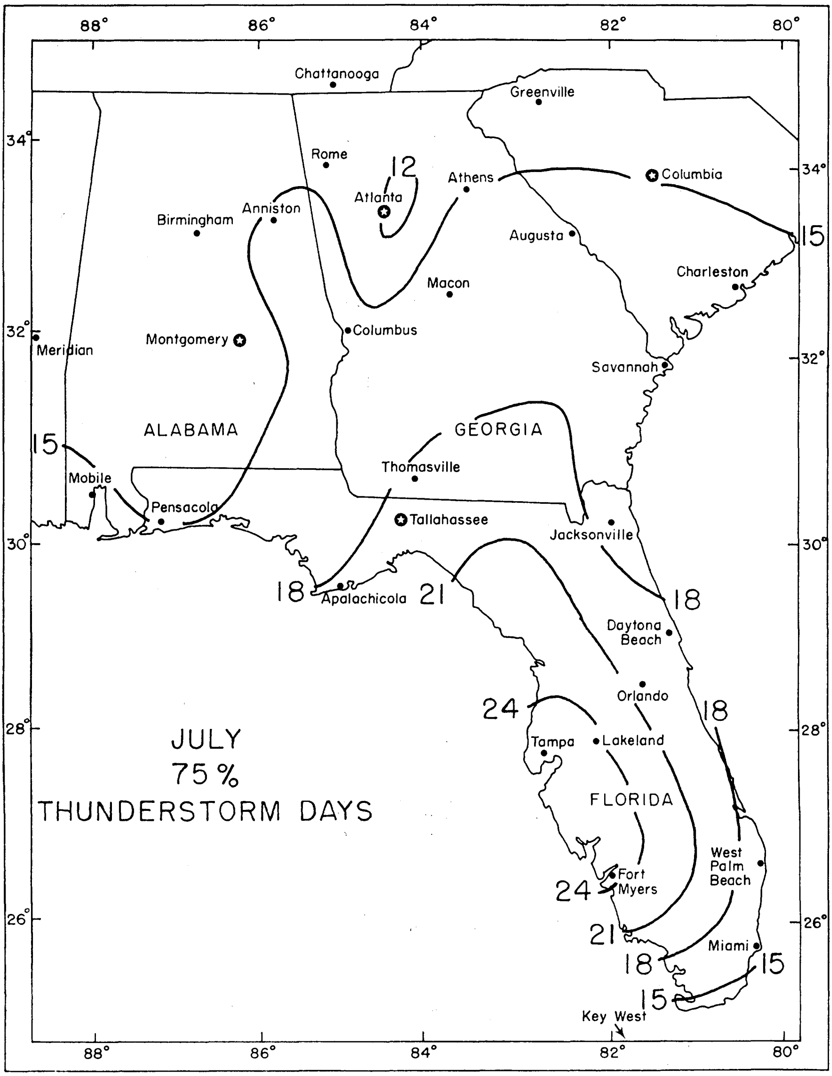


FIG. 17. Seventy-five percent thunderstorm days in July.

TABLE 9. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT AUGUSTA, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.67	0.53	0.06	0.01	0.00	0.00	0.00	0.00	0.07	0.37	0.30	0.59	0.53
1	0.84	0.77	0.23	0.07	0.02	0.00	0.00	0.00	0.22	0.74	0.66	0.90	0.87
2	0.92	0.88	0.47	0.19	0.06	0.00	0.00	0.00	0.41	0.92	0.88	0.98	0.97
3	0.96	0.94	0.69	0.37	0.14	0.01	0.00	0.01	0.59	0.98	0.97	1.00	1.00
4	0.98	0.97	0.85	0.56	0.27	0.03	0.00	0.03	0.73	1.00	0.99		
5	0.99	0.99	0.93	0.73	0.42	0.07	0.01	0.07	0.83		1.00		
6	0.99	0.99	0.98	0.85	0.58	0.14	0.02	0.14	0.90				
7	1.00	1.00	0.99	0.92	0.73	0.24	0.05	0.23	0.94				
8			1.00	0.97	0.83	0.35	0.10	0.35	0.97				
9				0.99	0.91	0.48	0.16	0.47	0.98				
10				0.99	0.95	0.60	0.24	0.60	0.99				
11				1.00	0.98	0.72	0.34	0.71	1.00				
12					0.99	0.81	0.45	0.80					
13					1.00	0.87	0.56	0.87					
14						0.92	0.66	0.92					
15						0.96	0.75	0.96					
16						0.98	0.83	0.98					
17						0.99	0.88	0.99					
18						0.99	0.93	0.99					
19						1.00	0.95	1.00					
20							0.97						
21							0.98						
22							0.99						
23							1.00						

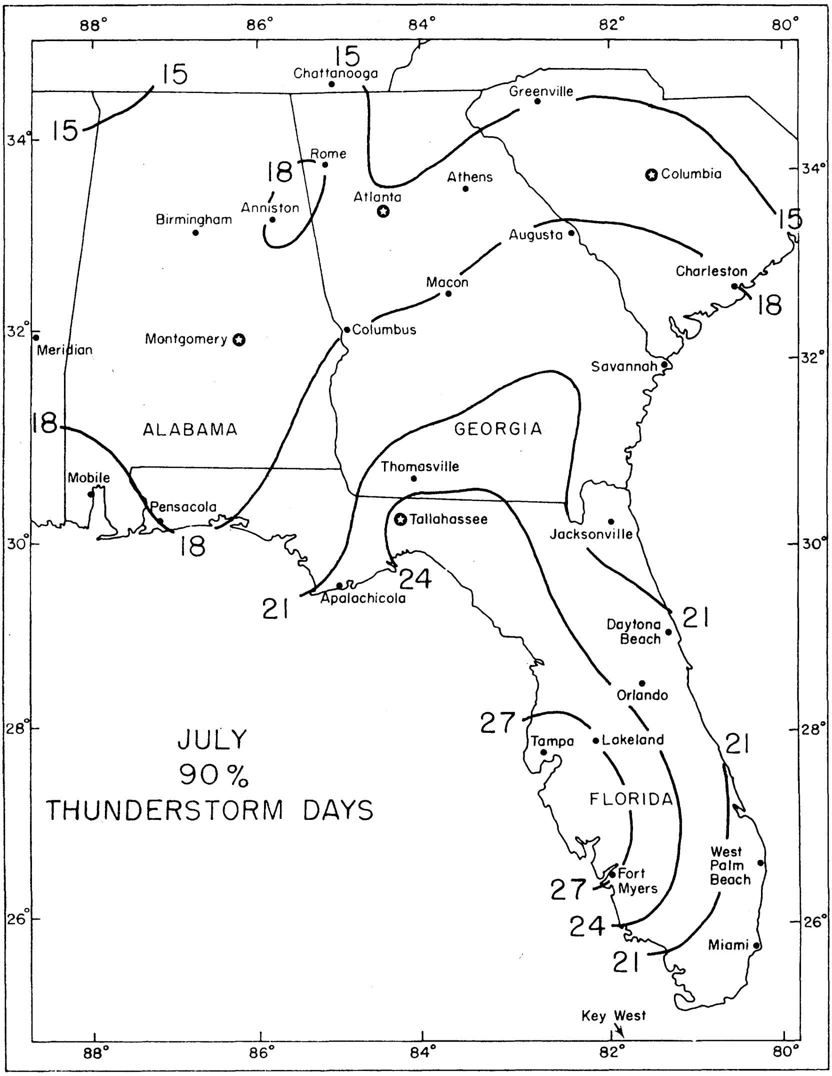


FIG. 18. Ninety percent thunderstorm days in July.

TABLE 10. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT BIRMINGHAM, ALABAMA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.26	0.21	0.07	0.01	0.00	0.00	0.00	0.00	0.03	0.30	0.18	0.29	0.14
1	0.62	0.44	0.14	0.04	0.01	0.00	0.00	0.00	0.15	0.66	0.49	0.65	0.42
2	0.85	0.64	0.20	0.11	0.04	0.01	0.00	0.00	0.15	0.66	0.49	0.65	0.42
3	0.95	0.77	0.38	0.25	0.11	0.03	0.01	0.02	0.56	0.97	0.91	0.96	0.86
4	0.99	0.86	0.58	0.42	0.21	0.07	0.02	0.05	0.74	0.99	0.97	0.99	0.95
5	1.00	0.92	0.74	0.59	0.35	0.14	0.05	0.11	0.87	1.00	0.99	1.00	0.98
6		0.95	0.86	0.74	0.51	0.25	0.09	0.19	0.94		1.00		1.00
7		0.97	0.93	0.85	0.66	0.38	0.15	0.31	0.98				
8		0.99	0.97	0.92	0.78	0.51	0.22	0.44	0.99				
9		0.99	0.99	0.96	0.87	0.64	0.31	0.57	1.00				
10		1.00	1.00	0.98	0.93	0.76	0.41	0.69					
11				0.99	0.98	0.84	0.51	0.79					
12				1.00	0.99	0.91	0.60	0.87					
13					1.00	0.95	0.68	0.92					
14						0.97	0.76	0.95					
15						0.99	0.82	0.98					
16						0.99	0.87	0.99					
17						1.00	0.91	0.99					
18							0.94	1.00					
19							0.96						
20							0.97						
21							0.98						
22							0.99						
23							0.99						
24							1.00						

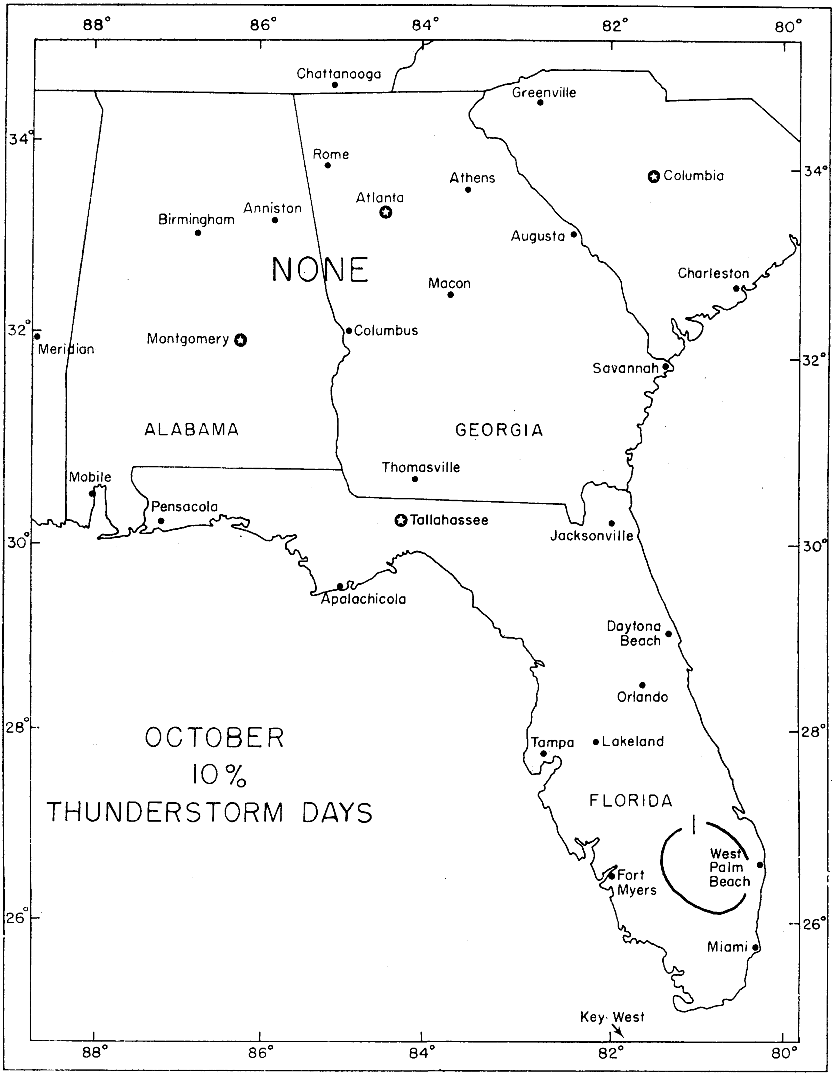


FIG. 19. Ten percent thunderstorm days in October.

TABLE 11. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT CHARLESTON, SOUTH CAROLINA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.55	0.46	0.20	0.05	0.01	0.00	0.00	0.00	0.01	0.37	0.56	0.77	0.72
1	0.88	0.77	0.46	0.20	0.05	0.00	0.00	0.00	0.04	0.74	0.82	0.93	0.92
2	0.98	0.91	0.66	0.43	0.12	0.00	0.00	0.00	0.12	0.92	0.93	0.98	0.97
3	1.00	0.97	0.80	0.65	0.22	0.01	0.00	0.01	0.26	0.98	0.97	0.99	0.99
4		0.99	0.89	0.82	0.33	0.03	0.00	0.03	0.43	1.00	0.99	1.00	1.00
5		1.00	0.94	0.92	0.45	0.06	0.00	0.06	0.60		1.00		
6			0.97	0.97	0.55	0.12	0.01	0.11	0.75				
7			0.98	0.99	0.65	0.20	0.03	0.17	0.86				
8			0.99	1.00	0.73	0.31	0.06	0.25	0.93				
9			1.00		0.80	0.43	0.10	0.35	0.97				
10					0.85	0.56	0.16	0.45	0.99				
11					0.89	0.67	0.24	0.54	0.99				
12					0.92	0.77	0.34	0.64	1.00				
13					0.95	0.85	0.44	0.72					
14					0.96	0.91	0.55	0.79					
15					0.97	0.94	0.65	0.85					
16					0.98	0.97	0.74	0.89					
17					0.99	0.98	0.81	0.92					
18					0.99	0.99	0.87	0.95					
19					1.00	1.00	0.91	0.97					
20							0.95	0.99					
21							0.97	0.99					
22							0.98	0.99					
23							0.99	1.00					
24							0.99						
25							1.00						

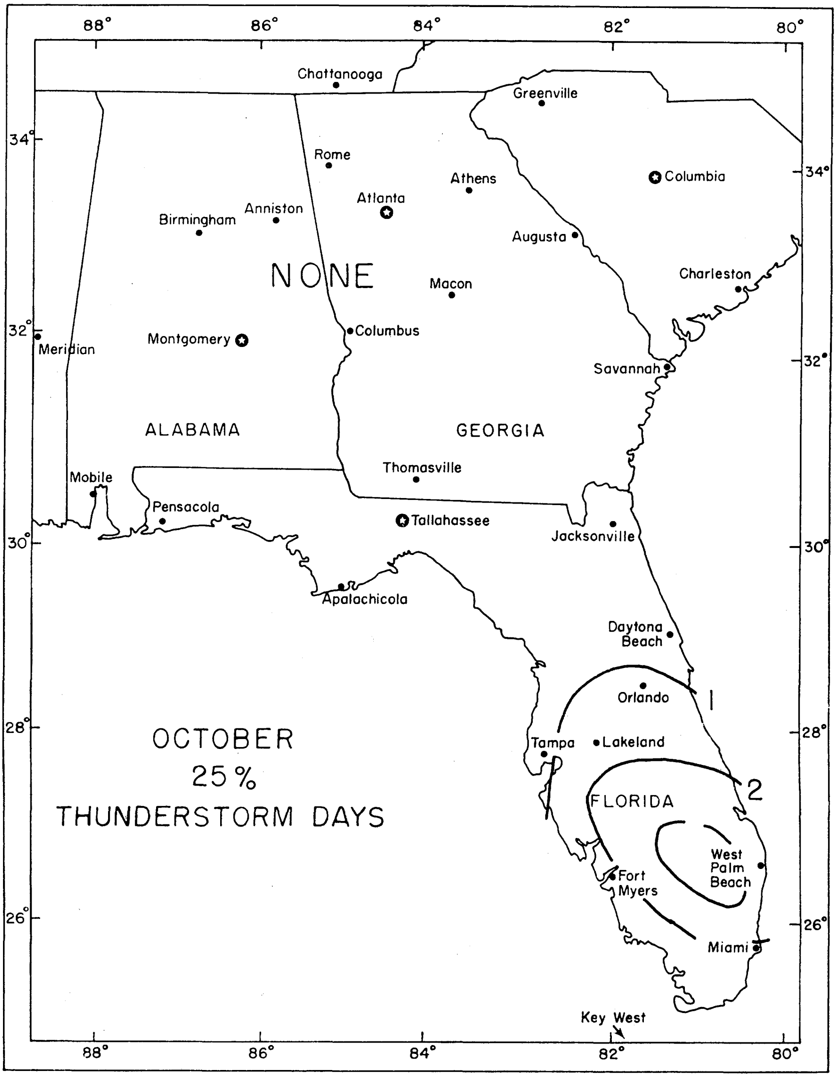


FIG. 20. Twenty-five thunderstorm days in October.

TABLE 12. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT CHATTANOOGA, TENNESSEE

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.24	0.25	0.03	0.01	0.00	0.00	0.00	0.00	0.03	0.25	0.30	0.66	0.50
1	0.58	0.51	0.14	0.05	0.01	0.00	0.00	0.00	0.12	0.59	0.66	0.85	0.65
2	0.83	0.70	0.32	0.15	0.03	0.00	0.00	0.01	0.30	0.83	0.88	0.93	0.87
3	0.94	0.83	0.54	0.30	0.07	0.02	0.00	0.02	0.51	0.95	0.97	0.96	0.96
4	0.98	0.91	0.73	0.48	0.16	0.04	0.01	0.05	0.70	0.99	0.99	0.98	0.99
5	1.00	0.95	0.86	0.66	0.28	0.09	0.02	0.11	0.84	1.00	1.00	0.99	1.00
6		0.97	0.93	0.80	0.42	0.17	0.05	0.20	0.92			1.00	
7		0.99	0.97	0.89	0.57	0.27	0.10	0.32	0.97				
8		0.99	0.99	0.95	0.70	0.40	0.17	0.45	0.99				
9		1.00	1.00	0.98	0.81	0.53	0.27	0.58	1.00				
10				0.99	0.89	0.65	0.38	0.70					
11				1.00	0.94	0.76	0.49	0.80					
12					0.97	0.84	0.61	0.90					
13					0.98	0.90	0.71	0.93					
14					0.99	0.94	0.80	0.96					
15					1.00	0.97	0.86	0.98					
16						0.98	0.91	0.99					
17						0.99	0.95	0.99					
18						1.00	0.97	1.00					
19							0.98						
20							0.99						
21							1.00						

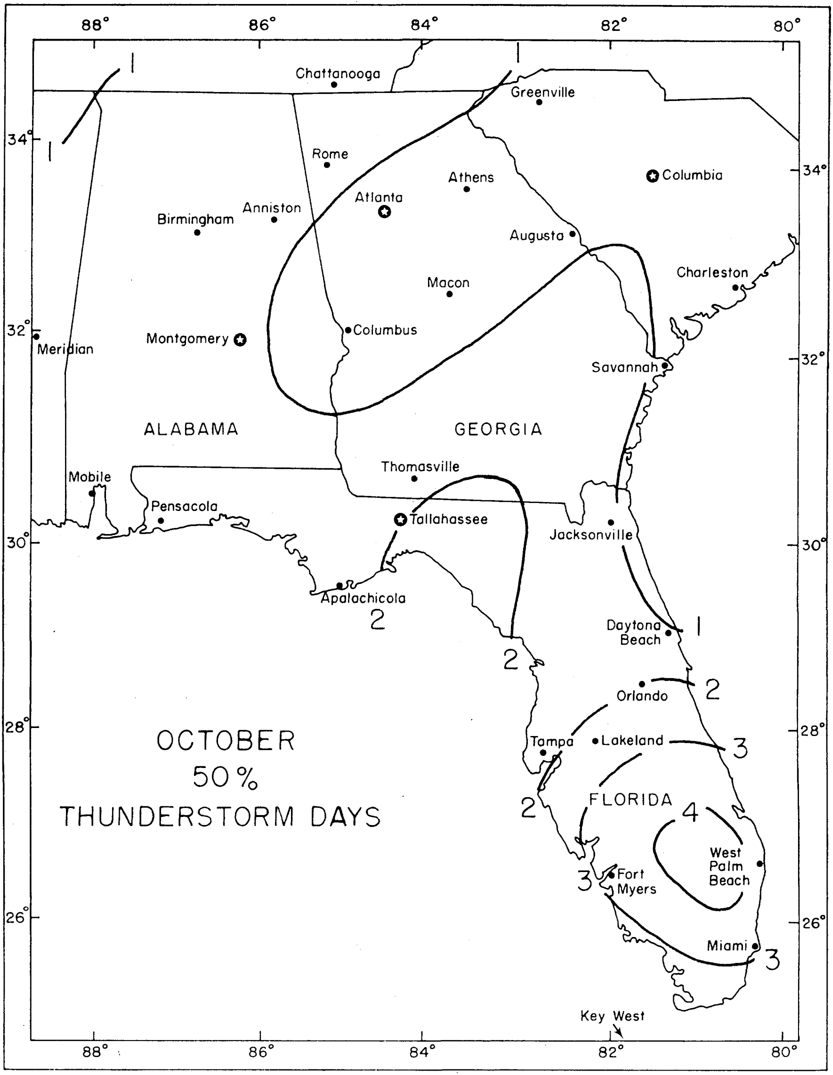


FIG. 21. Fifty percent thunderstorm days in October.

Table 13. Cumulative Probabilities of the Number of Monthly Thunderstorm Days and Annual Hail Days at Columbia, South Carolina

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.64	0.44	0.10	0.03	0.01	0.00	0.00	0.00	0.03	0.32	0.55	0.81	0.43
1	0.92	0.67	0.32	0.13	0.03	0.01	0.00	0.00	0.13	0.69	0.88	0.93	0.79
2	0.99	0.80	0.58	0.31	0.10	0.03	0.00	0.00	0.30	0.89	0.98	0.97	0.95
3	1.00	0.88	0.79	0.53	0.23	0.07	0.00	0.01	0.52	0.97	1.00	0.99	0.99
4		0.93	0.91	0.72	0.39	0.13	0.00	0.03	0.71	0.99		1.00	1.00
5		0.96	0.97	0.85	0.56	0.21	0.01	0.08	0.84	1.00			
6		0.97	0.99	0.93	0.72	0.30	0.03	0.14	0.93				
7		0.98	1.00	0.97	0.83	0.40	0.06	0.24	0.97				
8		0.99		0.99	0.91	0.51	0.11	0.36	0.99				
9		0.99		1.00	0.96	0.60	0.18	0.48	1.00				
10		1.00			0.98	0.69	0.27	0.61					
11					0.99	0.76	0.38	0.72					
12					1.00	0.82	0.49	0.81					
13						0.87	0.60	0.88					
14						0.91	0.70	0.93					
15						0.93	0.79	0.96					
16						0.95	0.85	0.98					
17						0.97	0.90	0.99					
18						0.98	0.94	0.99					
19						0.99	0.96	1.00					
20						0.99	0.98						
21						0.99	0.99						
22						1.00	0.99						
23							1.00						

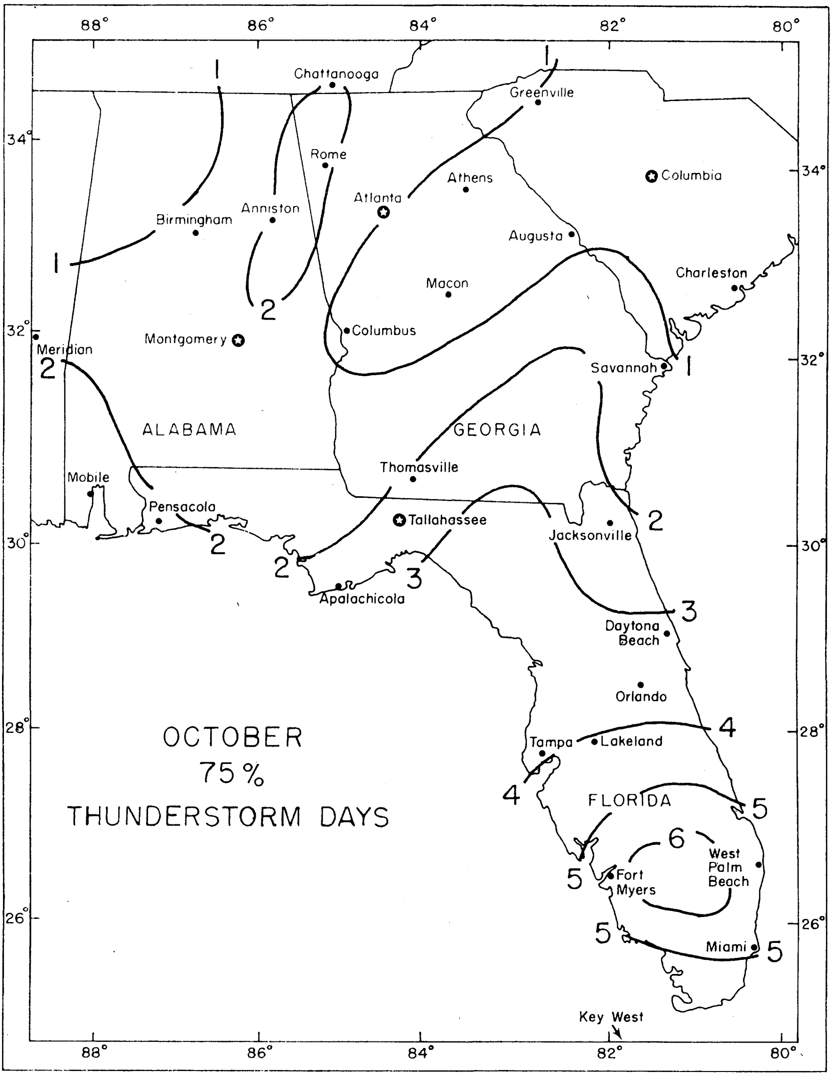


FIG. 22. Seventy-five percent thunderstorm days in October.

TABLE 14. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT COLUMBUS, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.33	0.32	0.04	0.01	0.00	0.00	0.00	0.00	0.03	0.33	0.43	0.29	0.55
1	0.62	0.57	0.17	0.05	0.02	0.00	0.00	0.00	0.15	0.70	0.79	0.64	0.88
2	0.90	0.74	0.38	0.15	0.07	0.01	0.00	0.00	0.34	0.90	0.95	0.87	0.98
3	0.97	0.84	0.60	0.31	0.17	0.02	0.00	0.01	0.56	0.97	0.99	0.96	1.00
4	0.99	0.91	0.78	0.49	0.31	0.05	0.00	0.04	0.74	0.99	1.00	0.99	
5	1.00	0.95	0.89	0.67	0.48	0.11	0.01	0.08	0.87	1.00		1.00	
6		0.97	0.96	0.80	0.64	0.20	0.02	0.16	0.94				
7		0.98	0.98	0.90	0.77	0.32	0.04	0.27	0.98				
8		0.99	0.99	0.95	0.87	0.45	0.10	0.39	0.99				
9		0.99	1.00	0.98	0.93	0.58	0.13	0.52	1.00				
10		1.00		0.99	0.97	0.70	0.20	0.65					
11				1.00	0.98	0.80	0.29	0.75					
12					0.99	0.90	0.39	0.84					
13					1.00	0.93	0.50	0.90					
14						0.97	0.61	0.94					
15						0.98	0.70	0.97					
16						0.99	0.79	0.98					
17						0.99	0.85	0.99					
18						1.00	0.90	1.00					
19							0.94						
20							0.96						
21							0.98						
22							0.99						
23							0.99						
24							1.00						

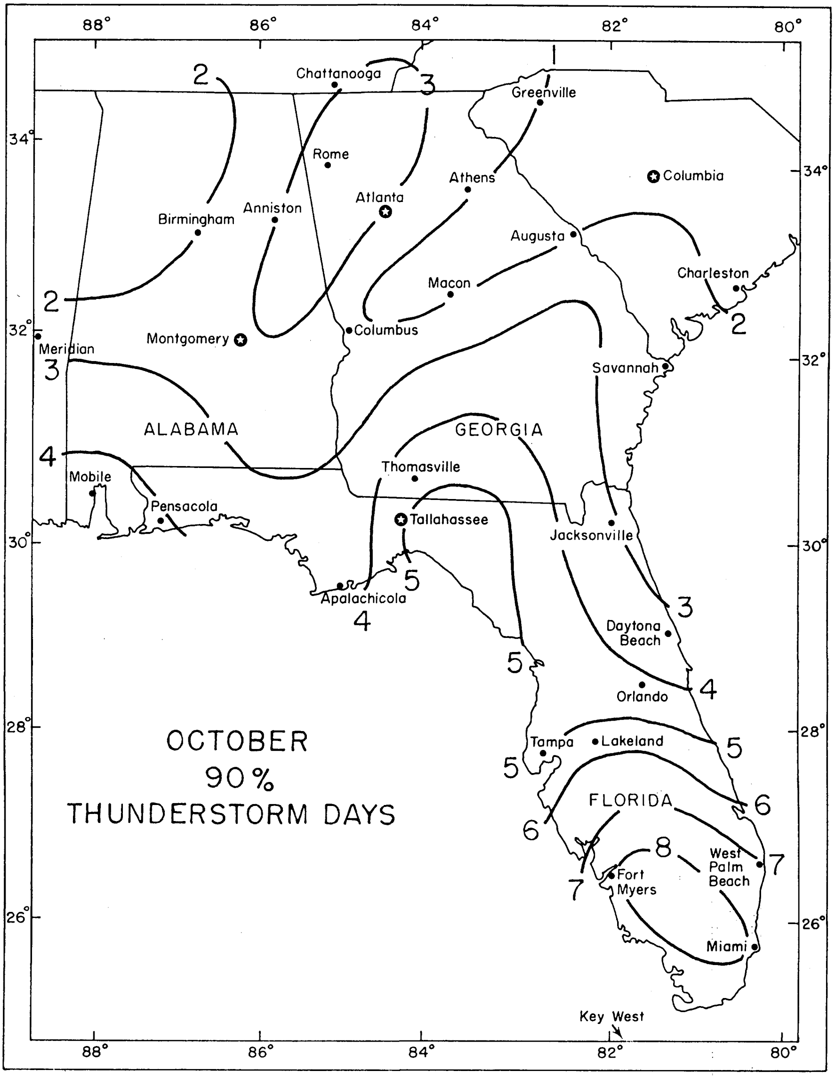


FIG. 23. Ninety percent thunderstorm days in October.

TABLE 15. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT DAYTONA BEACH, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.39	0.15	0.01	0.03	0.01	0.00	0.00	0.00	0.00	0.34	0.35	0.60	0.74
1	0.75	0.43	0.26	0.15	0.05	0.00	0.00	0.00	0.01	0.50	0.72	0.79	0.96
2	0.93	0.70	0.51	0.34	0.11	0.00	0.00	0.00	0.04	0.61	0.91	0.88	1.00
3	0.98	0.87	0.73	0.56	0.18	0.00	0.00	0.00	0.09	0.69	0.98	0.93	
4	1.00	0.96	0.87	0.74	0.27	0.00	0.00	0.00	0.16	0.75	1.00	0.96	
5		0.99	0.95	0.87	0.36	0.01	0.00	0.00	0.26	0.80		0.98	
6		1.00	0.98	0.94	0.45	0.03	0.00	0.01	0.37	0.84		0.99	
7			0.99	0.98	0.53	0.06	0.00	0.01	0.48	0.87		0.99	
8			1.00	0.99	0.61	0.11	0.01	0.03	0.59	0.89		0.99	
9				1.00	0.67	0.19	0.02	0.06	0.69	0.91		1.00	
10					0.73	0.28	0.05	0.10	0.77	0.92			
11					0.78	0.38	0.08	0.16	0.84	0.94			
12					0.83	0.49	0.13	0.23	0.90	0.95			
13					0.86	0.61	0.19	0.32	0.92	0.96			
14					0.89	0.71	0.27	0.42	0.95	0.96			
15					0.91	0.79	0.36	0.52	0.97	0.97			
16					0.93	0.86	0.46	0.62	0.98	0.97			
17					0.95	0.91	0.55	0.71	0.99	0.98			
18					0.96	0.94	0.65	0.79	0.99	0.98			
19					0.97	0.96	0.73	0.85	1.00	0.99			
20					0.98	0.98	0.80	0.90		0.99			
21					0.98	0.99	0.86	0.93		0.99			
22					0.99	0.99	0.90	0.96		0.99			
23					0.99	1.00	0.93	0.97		0.99			
24					0.99		0.96	0.98		0.99			
25					0.99		0.97	0.99		0.99			
26					1.00		0.98	1.00		1.00			
27							0.99						
28							0.99						
29							1.00						

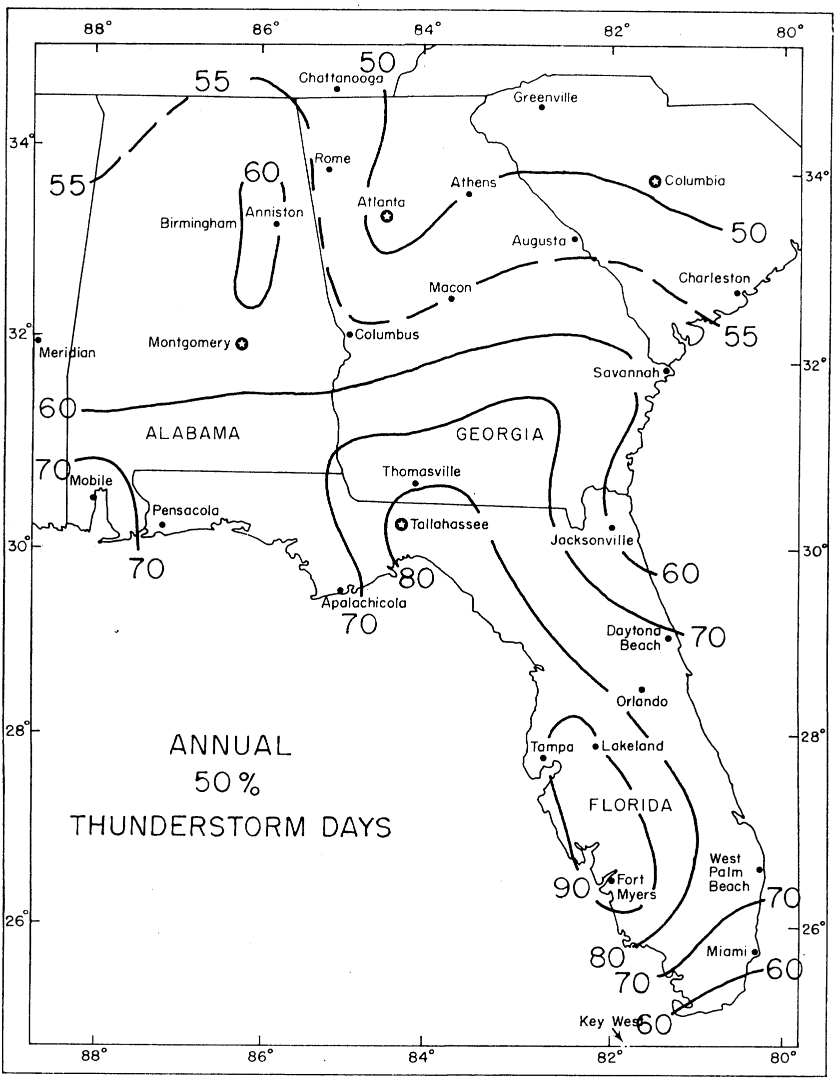


FIG. 24. Fifty percent thunderstorm days on an annual basis.

TABLE 16. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT FORT MYERS, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.62	0.21	0.22	0.16	0.00	0.00	0.00	0.00	0.00	0.06	0.33	0.50	0.90
1	0.84	0.54	0.45	0.33	0.01	0.00	0.00	0.00	0.00	0.17	0.70	0.84	0.95
2	0.94	0.80	0.62	0.49	0.04	0.00	0.00	0.00	0.00	0.31	0.90	0.97	0.98
3	0.97	0.93	0.75	0.61	0.10	0.00	0.00	0.00	0.00	0.45	0.97	0.99	0.99
4	0.99	0.98	0.84	0.71	0.17	0.00	0.00	0.00	0.00	0.58	0.99	1.00	0.99
5	1.00	0.99	0.90	0.79	0.27	0.00	0.00	0.00	0.00	0.68	1.00		1.00
6		1.00	0.93	0.85	0.38	0.00	0.00	0.00	0.01	0.77			
7			0.96	0.89	0.49	0.01	0.00	0.00	0.02	0.83			
8			0.97	0.92	0.59	0.03	0.00	0.00	0.04	0.88			
9			0.98	0.94	0.68	0.05	0.00	0.00	0.07	0.92			
10			0.99	0.96	0.76	0.09	0.00	0.00	0.11	0.94			
11			0.99	0.97	0.83	0.14	0.00	0.01	0.18	0.96			
12			1.00	0.98	0.88	0.21	0.01	0.02	0.26	0.97			
13				0.99	0.91	0.30	0.02	0.03	0.35	0.98			
14				0.99	0.94	0.40	0.03	0.05	0.46	0.99			
15				0.99	0.96	0.50	0.05	0.08	0.56	0.99			
16				0.99	0.97	0.60	0.07	0.13	0.65	1.00			
17				1.00	0.98	0.69	0.11	0.18	0.74				
18					0.99	0.77	0.16	0.25	0.81				
19					0.99	0.83	0.22	0.32	0.87				
20					1.00	0.88	0.29	0.40	0.91				
21						0.92	0.37	0.49	0.94				
22						0.95	0.45	0.57	0.97				
23						0.97	0.53	0.65	0.98				
24						0.98	0.61	0.73	0.99				
25						0.99	0.69	0.79	0.99				
26						0.99	0.76	0.84	1.00				
27						1.00	0.81	0.89					
28							0.86	0.92					
29							0.90	0.95					
30							0.93	0.96					
31							1.00	1.00					

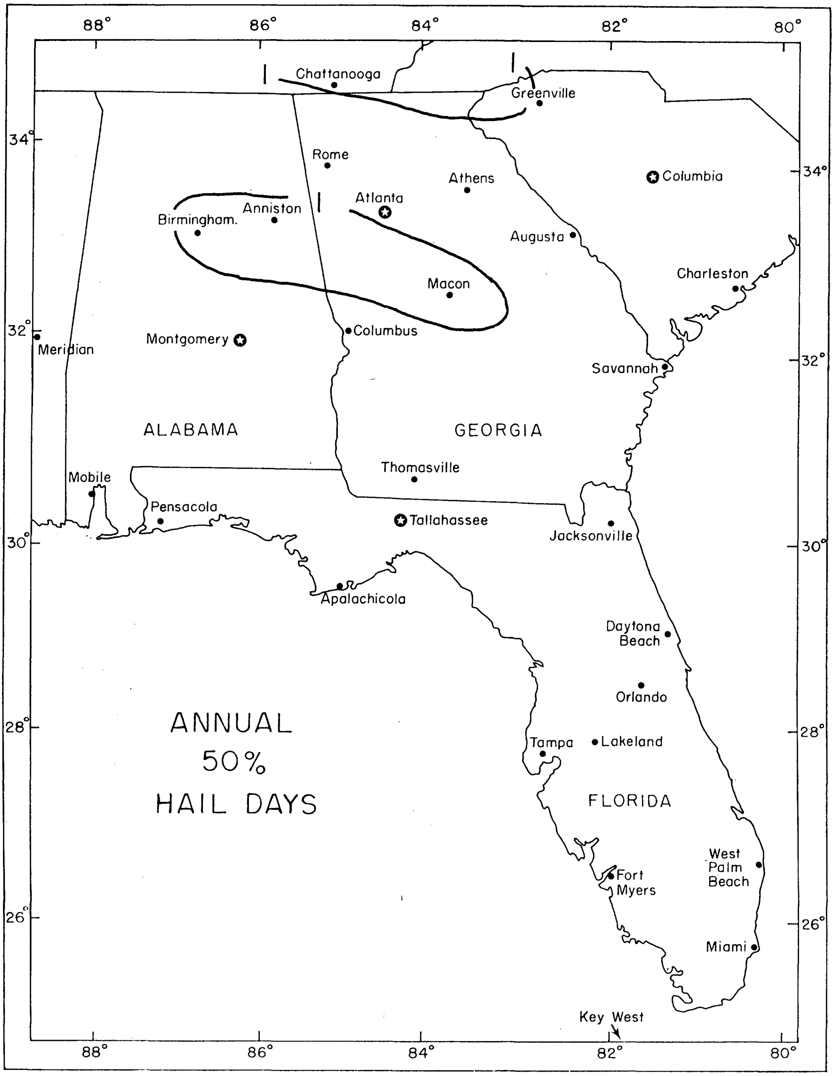


FIG. 25. Fifty percent hail days on an annual basis.

TABLE 17. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT GREENVILLE, SOUTH CAROLINA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.60	0.48	0.13	0.03	0.00	0.00	0.00	0.00	0.06	0.28	0.67	0.69	0.26
1	0.83	0.74	0.36	0.15	0.02	0.00	0.00	0.00	0.24	0.64	0.87	0.95	0.62
2	0.93	0.87	0.58	0.34	0.08	0.01	0.00	0.01	0.48	0.87	0.94	0.99	0.90
3	0.97	0.94	0.75	0.56	0.18	0.03	0.00	0.04	0.70	0.96	0.98	1.00	0.96
4	0.99	0.97	0.86	0.74	0.33	0.07	0.01	0.10	0.85	0.99	0.99		0.98
5	0.99	0.99	0.93	0.87	0.50	0.14	0.03	0.20	0.94	1.00	1.00		1.00
6	1.00	0.99	0.96	0.94	0.66	0.24	0.07	0.32	0.98				
7		1.00	0.98	0.98	0.79	0.36	0.13	0.46	0.99				
8			0.99	0.99	0.88	0.50	0.21	0.60	1.00				
9			1.00	1.00	0.93	0.63	0.31	0.72					
10					0.97	0.74	0.43	0.82					
11					0.99	0.83	0.55	0.89					
12					0.99	0.90	0.66	0.94					
13					1.00	0.94	0.76	0.97					
14						0.97	0.83	0.98					
15						0.98	0.89	0.99					
16						0.99	0.93	1.00					
17						1.00	0.96						
18							0.98						
19							0.99						
20							0.99						
21							1.00						

TABLE 18. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT JACKSONVILLE, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.63	0.36	0.17	0.06	0.01	0.00	0.00	0.00	0.00	0.35	0.65	0.57	0.46
1	0.84	0.72	0.38	0.20	0.04	0.00	0.00	0.00	0.02	0.62	0.87	0.78	0.74
2	0.93	0.91	0.57	0.38	0.10	0.00	0.00	0.00	0.08	0.78	0.95	0.88	0.88
3	0.97	0.98	0.71	0.57	0.20	0.01	0.00	0.00	0.19	0.88	0.98	0.93	0.95
4	0.98	1.00	0.81	0.72	0.33	0.03	0.00	0.01	0.34	0.94	0.99	0.96	0.98
5	0.99		0.88	0.83	0.46	0.07	0.00	0.02	0.51	0.97	1.00	0.98	0.99
6	1.00		0.93	0.90	0.59	0.14	0.01	0.04	0.67	0.98		0.99	1.00
7			0.95	0.94	0.70	0.23	0.02	0.08	0.80	0.99		0.99	
8			0.97	0.97	0.79	0.35	0.04	0.14	0.89	1.00		1.00	
9			0.98	0.98	0.86	0.47	0.07	0.22	0.94				
10			0.99	0.99	0.91	0.60	0.13	0.32	0.97				
11			0.99	1.00	0.94	0.71	0.19	0.43	0.99				
12			1.00		0.96	0.80	0.28	0.54	0.99				
13					0.98	0.87	0.38	0.65	1.00				
14					0.99	0.92	0.48	0.74					
15					0.99	0.96	0.58	0.82					
16					1.00	0.98	0.68	0.88					
17						0.99	0.76	0.92					
18						0.99	0.83	0.95					
19						1.00	0.88	0.97					
20							0.92	0.99					
21							0.95	0.99					
22							0.97	1.00					
23							0.98						
24							0.99						
25							0.99						
26							1.00						

TABLE 19. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT KEY WEST, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.46	0.26	0.18	0.14	0.04	0.00	0.00	00.0	0.00	0.02	0.46	0.41	0.85
1	0.82	0.62	0.49	0.42	0.13	0.00	0.00	0.00	0.00	0.10	0.82	0.77	0.99
2	0.96	0.85	0.76	0.69	0.26	0.01	0.00	0.00	0.01	0.25	0.96	0.94	1.00
3	0.99	0.95	0.91	0.86	0.41	0.03	0.00	0.00	0.03	0.45	0.99	0.99	
4	1.00	0.99	0.97	0.95	0.55	0.07	0.01	0.01	0.07	0.65	1.00	1.00	
5		1.00	0.99	0.98	0.67	0.13	0.04	0.02	0.12	0.80			
6			1.00	1.00	0.77	0.24	0.07	0.04	0.19	0.90			
7					0.84	0.36	0.13	0.08	0.28	0.95			
8					0.89	0.50	0.22	0.14	0.37	0.98			
9					0.93	0.63	0.33	0.23	0.47	0.99			
10					0.96	0.74	0.45	0.33	0.56	1.00			
11					0.97	0.83	0.57	0.44	0.65				
12					0.98	0.90	0.68	0.55	0.73				
13					0.99	0.94	0.77	0.66	0.79				
14					0.99	0.97	0.85	0.75	0.85				
15					1.00	0.98	0.90	0.83	0.89				
16						0.99	0.94	0.89	0.92				
17						1.00	0.97	0.93	0.94				
18							0.98	0.96	0.96				
19							0.99	0.98	0.97				
20							0.99	0.99	0.98				
21							1.00	0.99	0.99				
22								1.00	0.99				
23									1.00				

TABLE 20. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT KNOXVILLE, TENNESSEE

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.39	0.31	0.05	0.01	0.01	0.00	0.00	0.00	0.05	0.29	0.57	0.65	0.17
1	0.76	0.67	0.20	0.06	0.03	0.00	0.00	0.01	0.19	0.65	0.79	0.93	0.46
2	0.93	0.89	0.42	0.18	0.09	0.01	0.00	0.02	0.42	0.87	0.89	0.99	0.73
3	0.98	0.97	0.65	0.35	0.19	0.03	0.01	0.07	0.64	0.96	0.94	1.00	0.89
4	1.00	0.99	0.82	0.54	0.31	0.08	0.03	0.15	0.81	0.99	0.97		0.96
5		1.00	0.92	0.71	0.44	0.16	0.06	0.27	0.91	1.00	0.98		0.99
6			0.97	0.84	0.57	0.27	0.12	0.42	0.96		0.99		1.00
7			0.99	0.92	0.68	0.40	0.21	0.56	0.99		1.00		
8			1.00	0.96	0.78	0.54	0.31	0.70	1.00				
9				0.98	0.85	0.67	0.44	0.81					
10				0.99	0.90	0.77	0.56	0.88					
11				1.00	0.94	0.86	0.68	0.94					
12					0.96	0.92	0.78	0.97					
13					0.98	0.95	0.85	0.98					
14					0.99	0.97	0.91	0.99					
15					0.99	0.99	0.95	1.00					
16					1.00	0.99	0.97						
17						1.00	0.98						
18							0.99						
19							1.00						

TABLE 21. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT LAKELAND, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.42	0.21	0.05	0.07	0.00	0.00	0.00	0.00	0.00	0.11	0.31	0.44	0.61
1	0.73	0.54	0.19	0.20	0.01	0.00	0.00	0.00	0.00	0.29	0.67	0.70	0.91
2	0.86	0.79	0.37	0.37	0.04	0.00	0.00	0.00	0.00	0.48	0.89	0.84	0.99
3	0.94	0.93	0.56	0.53	0.08	0.00	0.00	0.00	0.00	0.65	0.97	0.92	1.00
4	0.97	0.98	0.71	0.66	0.15	0.00	0.00	0.00	0.01	0.77	0.99	0.96	
5	0.99	0.99	0.82	0.77	0.24	0.00	0.00	0.00	0.02	0.86	1.00	0.98	
6	1.00	1.00	0.90	0.85	0.34	0.00	0.00	0.00	0.04	0.91		0.99	
7			0.94	0.90	0.45	0.01	0.00	0.00	0.09	0.95		0.99	
8			0.97	0.94	0.56	0.01	0.00	0.00	0.15	0.97		1.00	
9			0.98	0.96	0.65	0.03	0.00	0.00	0.24	0.98			
10			0.99	0.98	0.73	0.05	0.00	0.01	0.34	0.99			
11			1.00	0.99	0.80	0.08	0.01	0.01	0.45	1.00			
12				0.99	0.86	0.13	0.01	0.03	0.57				
13				1.00	0.90	0.20	0.02	0.05	0.67				
14					0.93	0.28	0.04	0.08	0.77				
15					0.95	0.37	0.06	0.12	0.84				
16					0.97	0.46	0.10	0.17	0.90				
17					0.98	0.56	0.14	0.24	0.93				
18					0.99	0.65	0.20	0.31	0.96				
19					0.99	0.73	0.27	0.40	0.98				
20					0.99	0.80	0.34	0.49	0.99				
21					1.00	0.86	0.42	0.57	0.99				
22						0.90	0.51	0.65	1.00				
23						0.94	0.59	0.73					
24						0.96	0.67	0.79					
25						0.97	0.74	0.85					
26						0.98	0.80	0.90					
27						0.99	0.85	0.92					
28						0.99	0.89	0.95					
29						1.00	0.92	0.97					
30							0.95	0.98					
31							1.00	1.00					

TABLE 22. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT MACON, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.50	0.36	0.03	0.01	0.00	0.00	0.00	0.00	0.03	0.43	0.38	0.48	0.28
1	0.73	0.62	0.12	0.05	0.01	0.00	0.00	0.00	0.13	0.80	0.75	0.83	0.64
2	0.85	0.78	0.29	0.16	0.05	0.01	0.00	0.00	0.30	0.95	0.93	0.96	0.86
3	0.91	0.87	0.50	0.32	0.13	0.02	0.00	0.01	0.52	0.99	0.98	0.99	0.96
4	0.95	0.93	0.69	0.50	0.26	0.05	0.00	0.03	0.71	1.00	1.00	1.00	0.99
5	0.97	0.96	0.83	0.67	0.41	0.11	0.01	0.07	0.84				1.00
6	0.98	0.98	0.92	0.81	0.57	0.19	0.02	0.13	0.93				
7	0.99	0.99	0.97	0.90	0.71	0.31	0.04	0.22	0.97				
8	0.99	0.99	0.99	0.95	0.82	0.44	0.07	0.34	0.99				
9	1.00	1.00	1.00	0.98	0.90	0.57	0.13	0.46	1.00				
10				0.99	0.95	0.69	0.20	0.59					
11				1.00	0.97	0.79	0.29	0.70					
12					0.99	0.87	0.39	0.79					
13					0.99	0.92	0.50	0.87					
14					1.00	0.95	0.61	0.92					
15						0.97	0.70	0.95					
16						0.99	0.78	0.97					
17						0.99	0.85	0.99					
18						1.00	0.90	0.99					
19							0.94	1.00					
20							0.96						
21							0.98						
22							0.99						
23							0.99						
24							1.00						

TABLE 23. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT MERIDIAN, MISSISSIPPI

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.24	0.17	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.34	0.28	0.21	0.73
1	0.58	0.39	0.08	0.03	0.01	0.01	0.00	0.00	0.14	0.63	0.54	04.7	0.89
2	0.83	0.59	0.21	0.09	0.05	0.04	0.00	0.01	0.30	0.82	0.73	0.68	0.95
3	0.94	0.74	0.40	0.21	0.13	0.09	0.00	0.03	0.47	0.91	0.84	0.82	0.98
4	0.98	0.84	0.59	0.37	0.26	0.17	0.01	0.06	0.63	0.96	0.91	0.91	0.99
5	1.00	0.90	0.75	0.55	0.41	0.28	0.02	0.13	0.75	0.98	0.95	0.95	1.00
6		0.94	0.87	0.70	0.57	0.39	0.05	0.23	0.85	0.99	0.97	0.98	
7		0.97	0.94	0.82	0.71	0.51	0.09	0.35	0.91	1.00	0.99	0.99	
8		0.98	0.97	0.90	0.82	0.62	0.16	0.49	0.95		0.99	0.99	
9		0.99	0.99	0.95	0.90	0.72	0.24	0.62	0.97		1.00	1.00	
10		0.99	1.00	0.98	0.95	0.80	0.35	0.73	0.98				
11		1.00		0.99	0.97	0.86	0.46	0.83	0.99				
12				1.00	0.98	0.91	0.58	0.89	1.00				
13					0.99	0.94	0.68	0.94					
14					1.00	0.96	0.77	0.97					
15						0.98	0.84	0.98					
16						0.99	0.90	0.99					
17						0.99	0.94	1.00					
18						0.99	0.96						
19						1.00	0.98						
20							0.99						
21							0.99						
22							1.00						

TABLE 24. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT MIAMI, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.61	0.60	0.39	0.09	0.01	0.00	0.00	0.00	0.00	0.05	0.46	0.62	0.65
1	0.85	0.83	0.65	0.26	0.04	0.00	0.00	0.00	0.00	0.16	0.82	0.83	0.93
2	0.94	0.95	0.81	0.46	0.10	0.00	0.00	0.00	0.00	0.30	0.96	0.92	0.99
3	0.98	0.97	0.90	0.64	0.20	0.01	0.00	0.00	0.01	0.46	0.99	0.96	1.00
4	0.99	0.99	0.95	0.77	0.32	0.03	0.00	0.00	0.03	0.60	1.00	0.98	
5	1.00	0.99	0.97	0.87	0.45	0.06	0.01	0.00	0.06	0.71		0.99	
6		1.00	0.99	0.93	0.58	0.10	0.01	0.01	0.12	0.80		1.00	
7			0.99	0.96	0.69	0.17	0.03	0.03	0.20	0.87			
8			1.00	0.98	0.78	0.24	0.06	0.05	0.31	0.92			
9				0.99	0.85	0.33	0.11	0.10	0.43	0.95			
10				0.99	0.90	0.43	0.18	0.16	0.55	0.97			
11				1.00	0.94	0.52	0.26	0.24	0.67	0.98			
12					0.96	0.61	0.36	0.33	0.77	0.99			
13					0.98	0.69	0.47	0.44	0.85	0.99			
14					0.99	0.76	0.57	0.54	0.90	1.00			
15					0.99	0.82	0.67	0.64	0.94				
16					1.00	0.87	0.76	0.73	0.97				
17						0.91	0.83	0.81	0.98				
18						0.93	0.88	0.87	0.99				
19						0.95	0.92	0.91	1.00				
20						0.97	0.95	0.94					
21						0.98	0.97	0.97					
22						0.99	0.98	0.98					
23						0.99	0.99	0.99					
24						0.99	1.00	0.99					
25						1.00		1.00					

TABLE 25. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT MOBILE, ALABAMA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.18	0.14	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.13	0.21	0.12	0.61
1	0.48	0.42	0.06	0.05	0.01	0.00	0.00	0.00	0.05	0.40	0.47	0.37	0.91
2	0.75	0.69	0.17	0.15	0.03	0.00	0.00	0.00	0.12	0.67	0.68	0.64	0.99
3	0.90	0.86	0.33	0.30	0.09	0.00	0.00	0.00	0.21	0.85	0.82	0.83	1.00
4	0.97	0.95	0.52	0.48	0.18	0.01	0.00	0.00	0.31	0.94	0.91	0.93	
5	0.99	0.98	0.69	0.66	0.31	0.03	0.00	0.01	0.41	0.98	0.95	0.98	
6	1.00	1.00	0.82	0.80	0.46	0.06	0.00	0.01	0.51	1.00	0.98	0.99	
7			0.91	0.89	0.61	0.11	0.00	0.03	0.61		0.99	1.00	
8			0.96	0.95	0.74	0.19	0.01	0.06	0.69		1.00		
9			0.98	0.98	0.84	0.28	0.02	0.11	0.76				
10			0.99	0.99	0.91	0.39	0.05	0.17	0.81				
11			1.00	1.00	0.95	0.51	0.08	0.25	0.86				
12					0.97	0.63	0.13	0.35	0.89				
13					0.99	0.73	0.19	0.46	0.92				
14					0.99	0.81	0.27	0.56	0.94				
15					1.00	0.87	0.36	0.66	0.96				
16						0.92	0.46	0.75	0.97				
17						0.95	0.55	0.82	0.98				
18						0.97	0.64	0.88	0.98				
19						0.98	0.73	0.92	0.99				
20						0.99	0.80	0.95	0.99				
21						1.00	0.85	0.97	0.99				
22							0.90	0.98	1.00				
23							0.93	0.99					
24							0.96	0.99					
25							0.97	1.00					
26							0.98						
27							0.99						
28							0.99						
29							1.00						

TABLE 26. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT MONTGOMERY, ALABAMA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.35	0.27	0.02	0.00	0.00	0.00	0.00	0.00	0.03	0.25	0.19	0.17	0.69
1	0.63	0.53	0.08	0.03	0.01	0.00	0.00	0.00	0.15	0.59	0.50	0.46	0.87
2	0.80	0.71	0.22	0.09	0.04	0.01	0.00	0.01	0.34	0.83	0.77	0.73	0.93
3	0.89	0.83	0.41	0.21	0.11	0.02	0.00	0.03	0.56	0.95	0.91	0.89	0.97
4	0.95	0.90	0.61	0.37	0.23	0.06	0.01	0.07	0.74	0.99	0.97	0.96	0.99
5	0.97	0.94	0.77	0.55	0.37	0.12	0.02	0.14	0.87	1.00	0.99	0.99	0.99
6	0.99	0.97	0.88	0.70	0.53	0.21	0.04	0.24	0.94		1.00	1.00	1.00
7	0.99	0.98	0.94	0.82	0.68	0.32	0.09	0.36	0.98				
8	1.00	0.99	0.98	0.90	0.80	0.46	0.15	0.50	0.99				
9		0.99	0.99	0.95	0.88	0.59	0.23	0.63	1.00				
10		1.00	1.00	0.98	0.94	0.71	0.34	0.74					
11				0.99	0.97	0.80	0.45	0.83					
12				1.00	0.98	0.88	0.56	0.90					
13					0.99	0.93	0.67	0.94					
14					1.00	0.96	0.76	0.97					
15						0.98	0.84	0.98					
16						0.99	0.89	0.99					
17						0.99	0.93	1.00					
18						1.00	0.96						
19							0.98						
20							0.99						
21							0.99						
22							1.00						

TABLE 27. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT NASHVILLE, TENNESSEE

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.21	0.31	0.02	0.00	0.00	0.00	0.00	0.00	0.03	0.24	0.37	0.34	0.22
1	0.54	0.56	0.11	0.03	0.00	0.00	0.00	0.00	0.14	0.58	0.64	0.71	0.46
2	0.79	0.73	0.27	0.08	0.02	0.01	0.00	0.01	0.32	0.83	0.80	0.91	0.65
3	0.93	0.84	0.47	0.19	0.05	0.03	0.01	0.05	0.54	0.94	0.89	0.98	0.79
4	0.98	0.91	0.67	0.35	0.12	0.08	0.02	0.11	0.73	0.98	0.94	1.00	0.87
5	0.99	0.95	0.82	0.52	0.23	0.16	0.05	0.20	0.86	1.00	0.97		0.93
6	1.00	0.97	0.91	0.68	0.36	0.27	0.10	0.33	0.93		0.98		0.96
7		0.98	0.96	0.80	0.51	0.40	0.18	0.47	0.97		0.99		0.98
8		0.99	0.98	0.89	0.64	0.54	0.28	0.61	0.99		1.00		0.99
9		0.99	0.99	0.94	0.76	0.67	0.40	0.73	1.00				0.99
10		1.00	1.00	0.97	0.85	0.77	0.52	0.83					1.00
11				0.99	0.91	0.86	0.64	0.90					
12				1.00	0.95	0.92	0.75	0.94					
13					0.98	0.95	0.83	0.97					
14					0.99	0.97	0.89	0.98					
15					0.99	0.99	0.93	0.99					
16					1.00	0.99	0.96	1.00					
17						1.00	0.98						
18							0.99						
19							0.99						
20							1.00						

TABLE 28. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT ORLANDO, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.47	0.19	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.10	0.43	0.45	0.43
1	0.74	0.51	0.35	0.17	0.05	0.00	0.00	0.00	0.00	0.32	0.79	0.81	0.79
2	0.88	0.77	0.62	0.38	0.11	0.00	0.00	0.00	0.01	0.58	0.94	0.95	0.94
3	0.95	0.91	0.82	0.60	0.19	0.00	0.00	0.00	0.04	0.79	0.99	0.99	0.99
4	0.98	0.97	0.93	0.78	0.29	0.00	0.00	0.00	0.09	0.91	1.00	1.00	1.00
5	0.99	0.99	0.98	0.89	0.39	0.01	0.00	0.00	0.18	0.97			
6	1.00	1.00	0.99	0.95	0.49	0.03	0.00	0.00	0.29	0.99			
7			1.00	0.98	0.59	0.06	0.00	0.01	0.43	1.00			
8				0.99	0.67	0.11	0.01	0.02	0.57				
9				1.00	0.75	0.18	0.01	0.05	0.70				
10					0.81	0.26	0.03	0.08	0.80				
11					0.85	0.37	0.05	0.13	0.88				
12					0.89	0.48	0.09	0.20	0.93				
13					0.92	0.59	0.14	0.28	0.96				
14					0.94	0.69	0.20	0.38	0.98				
15					0.96	0.78	0.28	0.48	0.99				
16					0.97	0.85	0.36	0.58	1.00				
17					0.98	0.90	0.45	0.67					
18					0.99	0.94	0.55	0.75					
19					0.99	0.96	0.64	0.82					
20					0.99	0.98	0.72	0.87					
21					1.00	0.99	0.79	0.91					
22						0.99	0.85	0.94					
23						1.00	0.89	0.97					
24							0.93	0.98					
25							0.95	0.99					
26							0.97	0.99					
27							0.98	1.00					
28							0.99						
29							0.99						
30							1.00						

TABLE 29. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT PENSACOLA, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.29	0.18	0.14	0.06	0.01	0.00	0.00	0.00	0.01	0.27	0.32	0.31	0.79
1	0.56	0.49	0.31	0.19	0.05	0.01	0.00	0.00	0.03	0.53	0.60	0.57	0.98
2	0.75	0.76	0.48	0.35	0.14	0.03	0.00	0.00	0.07	0.71	0.79	0.74	1.00
3	0.87	0.91	0.61	0.51	0.29	0.06	0.00	0.00	0.14	0.83	0.89	0.85	
4	0.93	0.97	0.72	0.65	0.48	0.12	0.00	0.00	0.23	0.90	0.95	0.91	
5	0.96	0.99	0.80	0.76	0.65	0.20	0.01	0.01	0.33	0.95	0.97	0.95	
6	0.98	1.00	0.86	0.84	0.79	0.29	0.03	0.03	0.43	0.97	0.99	0.97	
7	0.99		0.90	0.90	0.89	0.40	0.06	0.08	0.53	0.98	0.99	0.98	
8	1.00		0.93	0.93	0.94	0.50	0.11	0.12	0.62	0.99	1.00	0.99	
9			0.96	0.96	0.97	0.60	0.20	0.71	1.00		0.99		
10			0.97	0.98	0.99	0.69	0.26	0.29	0.77			1.00	
11			0.98	0.99	1.00	0.77	0.37	0.40	0.83				
12			0.99	0.99		0.83	0.48	0.51	0.87				
13			0.99	1.00		0.88	0.59	0.62	0.91				
14			0.99			0.91	0.69	0.72	0.93				
15			1.00			0.94	0.78	0.80	0.95				
16						0.96	0.84	0.87	0.97				
17						0.97	0.90	0.91	0.98				
18						0.98	0.94	0.95	0.98				
19						0.99	0.96	0.97	0.99				
20						0.99	0.98	0.98	0.99				
21						1.00	0.99	0.99	0.99				
22							0.99	0.99	1.00				
23							1.00	1.00					

TABLE 30. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT ROME, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.33	0.34	0.04	0.00	0.00	0.00	0.00	0.01	0.02	0.25	0.42	0.72	0.49
1	0.70	0.60	0.18	0.02	0.02	0.01	0.00	0.03	0.08	0.51	0.68	0.88	0.77
2	0.90	0.77	0.39	0.06	0.06	0.03	0.01	0.08	0.22	0.70	0.83	0.95	0.90
3	0.97	0.87	0.61	0.15	0.15	0.06	0.02	0.14	0.41	0.82	0.91	0.97	0.96
4	0.99	0.92	0.79	0.28	0.28	0.12	0.04	0.22	0.61	0.90	0.95	0.99	0.98
5	1.00	0.96	0.90	0.44	0.44	0.21	0.08	0.31	0.77	0.94	0.98	0.99	0.99
6		0.98	0.96	0.60	0.60	0.30	0.12	0.39	0.88	0.97	0.99	1.00	1.00
7		0.99	0.98	0.74	0.74	0.41	0.19	0.48	0.94	0.98	0.99		
8		0.99	0.99	0.84	0.84	0.52	0.26	0.56	0.98	0.99	1.00		
9		1.00	1.00	0.91	0.91	0.62	0.34	0.64	0.99	1.00			
10				0.96	0.96	0.71	0.42	0.70	1.00				
11				0.98	0.98	0.78	0.51	0.76					
12				0.99	0.99	0.84	0.59	0.81					
13				1.00	1.00	0.89	0.66	0.84					
14						0.92	0.73	0.88					
15						0.95	0.78	0.90					
16						0.97	0.83	0.93					
17						0.98	0.87	0.94					
18						0.99	0.90	0.96					
19						0.99	0.93	0.97					
20						0.99	0.95	0.97					
21						1.00	0.96	0.98					
22							0.97	0.99					
23							0.98	0.99					
24							0.99	0.99					
25							0.99	0.99					
26							0.99	1.00					
27							1.00						

TABLE 31. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT SAVANNAH, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.50	0.46	0.09	0.02	0.01	0.00	0.00	0.00	0.02	0.25	0.70	0.06	0.36
1	0.84	0.82	0.26	0.09	0.03	0.00	0.00	0.00	0.06	0.60	0.85	0.92	0.72
2	0.97	0.96	0.45	0.24	0.07	0.00	0.00	0.00	0.15	0.84	0.92	0.99	0.91
3	0.99	0.99	0.63	0.43	0.14	0.01	0.00	0.00	0.28	0.95	0.96	1.00	0.98
4	1.00	1.00	0.77	0.63	0.24	0.02	0.00	0.01	0.41	0.99	0.97		1.00
5			0.86	0.78	0.35	0.05	0.00	0.02	0.55	1.00	0.98		
6			0.92	0.89	0.47	0.10	0.01	0.05	0.06		0.99		
7			0.96	0.95	0.57	0.17	0.02	0.10	0.76		0.99		
8			0.98	0.98	0.06	0.27	0.03	0.16	0.84		1.00		
9			0.99	0.99	0.75	0.39	0.06	0.25	0.89				
10			0.99	1.00	0.82	0.51	0.11	0.36	0.93				
11			1.00		0.87	0.63	0.17	0.48	0.96				
12					0.91	0.73	0.25	0.59	0.97				
13					0.94	0.82	0.34	0.70	0.98				
14					0.96	0.88	0.44	0.78	0.99				
15					0.97	0.93	0.54	0.85	0.99				
16					0.98	0.96	0.64	0.91	1.00				
17					0.99	0.98	0.73	0.94					
18					0.99	0.99	0.80	0.97					
19					1.00	0.99	0.86	0.98					
20						1.00	0.91	0.99					
21							0.94	0.99					
22							0.96	1.00					
23							0.98						
24							0.99						
25							0.99						
26							1.00						

TABLE 32. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT TALLAHASSEE, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.24	0.15	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.26	0.35	0.30	0.61
1	0.58	0.44	0.09	0.06	0.00	0.00	0.00	0.00	0.02	0.51	0.64	0.66	0.91
2	0.85	0.71	0.24	0.17	0.01	0.00	0.00	0.00	0.05	0.70	0.81	0.88	0.99
3	0.94	0.88	0.44	0.34	0.04	0.00	0.00	0.00	0.12	0.82	0.91	0.97	1.00
4	0.98	0.96	0.64	0.53	0.10	0.00	0.00	0.00	0.20	0.89	0.96	0.99	
5	1.00	0.99	0.79	0.70	0.20	0.01	0.00	0.00	0.31	0.94	0.98	1.00	
6		1.00	0.89	0.83	0.32	0.02	0.00	0.00	0.43	0.96	0.99		
7			0.95	0.91	0.46	0.04	0.00	0.01	0.54	0.98	1.00		
8			0.98	0.96	0.60	0.07	0.00	0.02	0.65	0.99			
9			0.99	0.98	0.72	0.13	0.01	0.04	0.74	0.99			
10			1.00	0.99	0.82	0.20	0.01	0.07	0.81	1.00			
11				1.00	0.89	0.29	0.03	0.12	0.87				
12					0.94	0.40	0.05	0.18	0.91				
13					0.97	0.50	0.08	0.26	0.94				
14					0.98	0.61	0.12	0.35	0.96				
15					0.99	0.71	0.18	0.45	0.98				
16					1.00	0.79	0.25	0.55	0.98				
17						0.85	0.33	0.64	0.99				
18						0.90	0.42	0.73	0.99				
19						0.94	0.51	0.80	1.00				
20						0.96	0.60	0.86					
21						0.98	0.68	0.90					
22						0.99	0.76	0.94					
23						0.99	0.82	0.96					
24						1.00	0.87	0.97					
25							0.91	0.98					
26							0.94	0.99					
27							0.96	1.00					
28							0.97						
29							0.98						
30							0.99						
31							1.00						

TABLE 33. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT TAMPA, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.43	0.26	0.08	0.05	0.03	0.00	0.00	0.00	0.00	0.17	0.42	0.43	0.61
1	0.80	0.60	0.29	0.20	0.09	0.00	0.00	0.00	0.00	0.38	0.68	0.71	0.91
2	0.95	0.84	0.55	0.43	0.19	0.00	0.00	0.00	0.00	0.57	0.83	0.87	0.99
3	0.99	0.95	0.76	0.65	0.29	0.00	0.00	0.00	0.01	0.72	0.91	0.94	1.00
4	1.00	0.99	0.90	0.82	0.40	0.00	0.00	0.00	0.02	0.82	0.95	0.97	
5		1.00	0.96	0.92	0.51	0.00	0.00	0.00	0.04	0.89	0.98	0.99	
6			0.99	0.97	0.60	0.01	0.00	0.00	0.08	0.93	0.99	1.00	
7			1.00	0.99	0.69	0.02	0.00	0.00	0.15	0.96	0.99		
8				1.00	0.76	0.05	0.00	0.00	0.23	0.98	1.00		
9					0.81	0.09	0.00	0.00	0.33	0.99			
10					0.86	0.15	0.00	0.01	0.45	0.99			
11					0.89	0.22	0.01	0.02	0.57	1.00			
12					0.92	0.31	0.02	0.03	0.67				
13					0.94	0.42	0.03	0.06	0.76				
14					0.96	0.52	0.05	0.09	0.83				
15					0.97	0.62	0.08	0.14	0.89				
16					0.98	0.71	0.12	0.20	0.93				
17					0.98	0.79	0.17	0.27	0.96				
18					0.99	0.86	0.23	0.35	0.98				
19					0.99	0.90	0.31	0.44	0.99				
20					0.99	0.94	0.39	0.53	0.99				
21					1.00	0.96	0.47	0.61	1.00				
22						0.98	0.56	0.69					
23						0.99	0.64	0.76					
24						0.99	0.71	0.82					
25						1.00	0.78	0.87					
26							0.83	0.91					
27							0.88	0.94					
28							0.91	0.96					
29							0.94	0.97					
30							0.96	0.98					
31							1.00	1.00					

TABLE 34. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT THOMASVILLE, GEORGIA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.48	0.17	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.36	0.57	0.55	0.63
1	0.73	0.47	0.13	0.08	0.02	0.00	0.00	0.00	0.04	0.60	0.77	0.78	0.92
2	0.86	0.74	0.31	0.18	0.06	0.00	0.00	0.00	0.09	0.74	0.87	0.89	0.99
3	0.92	0.90	0.52	0.31	0.12	0.00	0.00	0.00	0.17	0.84	0.93	0.94	1.00
4	0.96	0.97	0.71	0.46	0.21	0.01	0.00	0.00	0.28	0.90	0.96	0.97	
5	0.98	0.99	0.85	0.60	0.32	0.03	0.00	0.00	0.39	0.94	0.97	0.98	
6	0.99	1.00	0.93	0.72	0.44	0.06	0.01	0.01	0.51	0.96	0.98	0.99	
7	0.99		0.97	0.81	0.56	0.11	0.02	0.03	0.61	0.97	0.99	1.00	
8	1.00		0.99	0.88	0.66	0.18	0.04	0.05	0.70	0.98	0.99		
9			1.00	0.92	0.75	0.28	0.07	0.09	0.78	0.99	1.00		
10				0.95	0.82	0.38	0.12	0.15	0.84	0.99			
11				0.97	0.87	0.49	0.18	0.23	0.89	1.00			
12				0.98	0.91	0.60	0.26	0.33	0.92				
13				0.99	0.94	0.70	0.35	0.43	0.95				
14				1.00	0.96	0.79	0.44	0.54	0.96				
15					0.98	0.85	0.54	0.64	0.98				
16					0.99	0.90	0.64	0.73	0.98				
17					0.99	0.94	0.72	0.80	0.99				
18					0.99	0.96	0.80	0.86	0.99				
19					1.00	0.98	0.85	0.91	1.00				
20						0.99	0.90	0.94					
21						0.99	0.93	0.96					
22						1.00	0.96	0.98					
23							0.97	0.99					
24							0.98	0.99					
25							0.99	1.00					
26							1.00						

TABLE 35. CUMULATIVE PROBABILITIES OF THE NUMBER OF MONTHLY THUNDERSTORM DAYS AND ANNUAL HAIL DAYS AT WEST PALM BEACH, FLORIDA

Days	Probabilities by months												Hail
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0.55	0.22	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.01	0.35	0.55	0.61
1	0.88	0.56	0.37	0.28	0.01	0.00	0.00	0.00	0.00	0.05	0.72	0.88	0.91
2	0.98	0.81	0.64	0.45	0.04	0.00	0.00	0.00	0.00	0.16	0.91	0.98	0.99
3	1.00	0.93	0.83	0.60	0.10	0.00	0.00	0.00	0.00	0.32	0.98	1.00	1.00
4		0.98	0.93	0.72	0.21	0.00	0.00	0.00	0.01	0.50	1.00		
5		1.00	0.97	0.81	0.35	0.01	0.00	0.00	0.02	0.68			
6			0.99	0.87	0.50	0.02	0.01	0.00	0.05	0.81			
7			1.00	0.91	0.65	0.05	0.02	0.01	0.10	0.90			
8				0.94	0.77	0.10	0.04	0.02	0.17	0.95			
9				0.96	0.86	0.16	0.07	0.03	0.26	0.98			
10				0.97	0.92	0.24	0.12	0.06	0.36	0.99			
11				0.98	0.96	0.34	0.18	0.10	0.48	1.00			
12				0.99	0.98	0.45	0.26	0.16	0.59				
13				0.99	0.99	0.56	0.36	0.23	0.70				
14				1.00	1.00	0.66	0.46	0.32	0.79				
15						0.75	0.56	0.41	0.86				
16						0.83	0.66	0.51	0.91				
17						0.88	0.74	0.61	0.94				
18						0.93	0.82	0.70	0.97				
19						0.95	0.87	0.77	0.98				
20						0.97	0.91	0.84	0.99				
21						0.98	0.95	0.89	0.99				
22						0.99	0.97	0.92	1.00				
23						1.00	0.98	0.95					
24							0.99	0.97					
25							0.99	0.98					
26							1.00	0.99					
27								0.99					
28								1.00					

APPENDIX

I. Theoretical Considerations

The use of the negative binomial and Poisson distributions to fit rare meteorological events such as annual hail days and the annual frequency of typhoons and tornadoes has been discussed by Thom *(12,13)*. Thom studied the distribution of hail, a rare phenomenon. If the frequency of occurrence of hail is very low, then one would expect that the probability of hail in any given storm is independent of whether hail had occurred in previous storms. As a series of independent rare events, hail frequencies would be expected to be distributed as Poisson. As the frequency of occurrence of the hail storms increases, however, the assumption that successive hail storms are independent may no longer be true. Thus, as Thom *(12)* points out, if one storm had hail the next storm would be more likely to have hail also. This tends to make the successive storms dependent. This increased dependence lends itself to the negative binomial distribution.

While Thom's theoretical reasoning is accurate the results from this study do not consistently bear out his reasoning. Many stations which had high frequencies of annual thunderstorm day occurrences were still best explained by the Poisson distribution. Other stations which had a lower frequency of occurrence of annual thunderstorm days were best explained by the negative binomial distribution.

The Poisson distribution is given by:

$$f(x;\mu) = \frac{\mu^{x} e^{-\mu}}{x!} \qquad (1)$$

where μ is the population mean and $f(x;\mu)$ is probability of having exactly x occurrences of the given event during the period in question. Equation (1) can be expressed in natural logarithms as

$$\ln P = x \ln \bar{x} - \ln x! - \bar{x} \qquad (2)$$

where P is the probability of exactly x occurrences of the given event during the period in question and $\bar{x}$ is the sample mean.

Bliss and Fisher *(1)* give the negative binomial distribution as

$$f(x;k,p) = \frac{(k+x-1)!}{x!\,(k-1)!} \left[\frac{p^{x}}{(1+p)^{k+x}} \right] \qquad (3)$$

where $f(x;k,p)$ is the probability of x occurrences of the event during the period in question. The k and p are the distribution parameters which can be estimated from the sample by various methods. One approach to their estimation is through the method of moments. Essentially the technique consists of equating the first several moments of the population with the corresponding moments of the sample. One can obtain as many equations as are necessary to solve for the unknown distribution parameters. The first two moments, M_1 and M_2, of the negative binomial distribution are:

$$M_1 = \mu = kp \qquad M_2 = \sigma^2 = kp\,(1+p) \qquad (4)$$

Using the sample mean $\bar{x}$ as an estimate of the population mean, μ, and sample variance s^2 as an estimate of the population variance, σ^2, the two distribution parameters are initially estimated by:

$$k = \frac{\bar{x}^2}{s^2 - \bar{x}} \text{ and } p = \frac{s^2 - \bar{x}}{\bar{x}} \quad (5)$$

The density function of the negative binomial distribution can be expressed in natural logarithms as

$$\ln P = k \ln \left[\frac{1}{1+p}\right] + \ln R + x \ln \left[\frac{p}{p+1}\right] \quad (6)$$

where $R = \frac{(k+x-1)!}{x!\,(k-1)!}$ and P is the probability of x occurrences of the given event during the period in question.

The estimation of k and p by the method of moments is not always efficient. A means has been provided by Fisher *(6)* to test the efficiency (one estimator is said to be a more efficient estimator of some parameter than a second estimator if the mean square error obtained from using the first estimator is smaller than that from the second) of the method of moments. The equation used is

$$D = \left(1 + \frac{1}{p}\right)(k + 2) \quad (7)$$

If the value of D given by Equation (7) is greater than 20, the method of moments is satisfactory; however, if the value of D is less than 20 the parameters p and k should be estimated using the maximum likelihood method. Essentially this method consists of selecting the values of the parameters p and k which are under consideration and for which $f(x_1, x_2, \ldots, x_n; p,k)$, the probability of obtaining the sample values, is a maximum. The maximizing procedure consists of taking the partial derivative of the probability density function with respect to both p and k and equating the result to zero. Thus it is necessary to find the values of p and k which maximize

$$L = \prod_{i=1}^{n} f(x_i, p, k) \quad (8)$$

The procedure can be simplified by using natural logs

$$L_1 = \frac{\partial \ln L}{\partial p} = \frac{\Sigma x}{p} - \frac{nk + \Sigma x}{1 + p} = 0 \quad (9)$$

for n observations. From Equation (9) $\bar{x} = kp$ since $\Sigma x = n\bar{x}$. The partial derivative with respect to k can be obtained using a method by Haldane *(7)* which does not involve the use of gamma functions. The form of the Haldane equation used by Thom *(12)* is

$$L_2 = \frac{\partial \ln L}{\partial k} = kn \ln \left(1 + \frac{\bar{x}}{k}\right) - \left[(g_1 + g_2 + \ldots + g_r) + \frac{k}{k+1}(g_2 + g_3 + \ldots + g_r) + \ldots + \frac{k\,(g_r)}{k + r - 1}\right] = 0 \quad (10)$$

where $g_1, g_2, \ldots, g_r$ are observed frequencies for the number of thunderstorm or hail days; $x = 1, 2, \ldots, r$ (r is the largest x). In Equation (10) n is the number of years, $\bar{x}$ is the sample mean, and k is the initial moments parameter estimate. The final k can be determined by solving (10) iteratively, e.g., see Sakamoto (11).

The choice of which model (Poisson or negative binomial) to use is based on a hypothesis testing procedure which utilizes the chi-square distribution with n—1 degrees of freedom. The equation is given by

$$X^2_{n-1} = \frac{n \sum_{i=1}^{n} x^2_i}{\sum_{i=1}^{n} x_i} - \sum_{i=1}^{n} x_i \qquad (11)$$

where n is the number of observations in the sample and x is the number of thunderstorm or hail days. The .05 level of significance is used.

The details of the computational procedure utilized in arriving at the probabilities in the computer program can be found in Davis *(4)*.

II. Tests For Significance

The computed probabilities of thunderstorm and hail days were tested against the observed probabilities using the Kolmogorov-Smirnov (KS) test for significance.

The KS testing method was applied to the annual number of thunderstorm days at each of the 31 selected locations in the southeastern United States. Using the procedures described in previous sections, the computer program found that the Poisson distribution was adequate at 16 stations while at the remaining 15 stations the negative binomial distribution had been found to give the best fit. The KS testing was carried out to see if these selection procedures in the computer program were making statistically significant choices.

Crutcher, *et. al. (3)*, points out that the Poisson, chi-square and exponential distributions are special cases of the gamma distribution. The gamma distribution, the general distribution model, has shape parameters which range from 0 to 1. In terms of γ, the shape parameter for the chi-square distribution is equal to one-half the number of chi-square degrees of freedom. Thus for chi-square degrees of freedom 1, 2, 3,...,$<\infty$, the gamma shape parameters are 0.5, 1.0, 1.5, ...,$<\infty$, respectively. For even values of the chi-square degrees of freedom, the Poisson distribution holds. Thus for chi-square degrees of freedom equal to 2, 4, 6...,$<\infty$, the gamma shape parameters are 1, 2, 3, ...,$<\infty$, respectively. To test the Poisson distribution of goodness of fit, one must first determine the gamma shape factor from the chi-square degrees of freedom. Then using the shape factor, the critical KS value can be obtained from the tables provided by Lilliefors *(9)*. Stations used in this study had either 20, 25, or 30 years of data. Thus, the chi-square degrees of freedom were 19, 24, and 29, respectively. The gamma shape factors were thus 9.5, 12, and 14.5, respectively. The critical values for the KS test at the .10 level of significance were obtained from the Lilliefors tables either directly or by interpolation between tables of fixed shape value designations.

No specific table of KS values for the negative binomial distribution are available at present, therefore, the distribution-free KS test discussed by Massey *(10)* was used. Since the test is a general one, the level of significance was chosen to be .20 to allow for a more rigorous approach. Again it was found that at all the stations whose computed distribution for annual thunderstorm days was negative binomial the testing procedure accepted the hypothesis that the sample was distributed as negative binomial.

Thus on the basis of the KS testing procedure outlined above, the computed probabilities provided a statistically significant fit to the observed values for annual thunderstorm days at the 31 stations used in this study.

Theoretically, when the variance is equal to the mean, the distribution is Poisson. When the variance is greater than the mean, the distribution is negative binomial. In this study, the Poisson model was selected in all cases when the mean was greater than the variance. In some cases, however, the Poisson distribution was considered adequate in spite of the variance being larger than the mean. Therefore, the model selection was explored further by calculating probabilities for both distributions and comparing it with the observed frequency. Examples are shown in Figures A and B for Lakeland, Florida, and Atlanta, Georgia. The plot of the data shows that the negative binomial fits the observed data better than the Poisson. In these two cases, the variance was greater than the mean and the negative binomial was properly selected. In Figure C the comparison of the two distributions with the observed data at Mobile, Alabama is shown. In this case, the variance was slightly greater than the mean, but the Poisson model was selected. Inspection of the data suggests that either model could have been chosen since the differences are considered minor from a practical viewpoint. The closeness of the two distributions when the variance is greater than the mean indicate that even though the chi-square test of hypothesis is accepted, and the Poisson is considered adequate (see Equation 11), the negative binomial could still be fitted without significant error. However, the authors chose to follow the more objective selection procedure – that of using the chi-square test of hypothesis in the model selection.

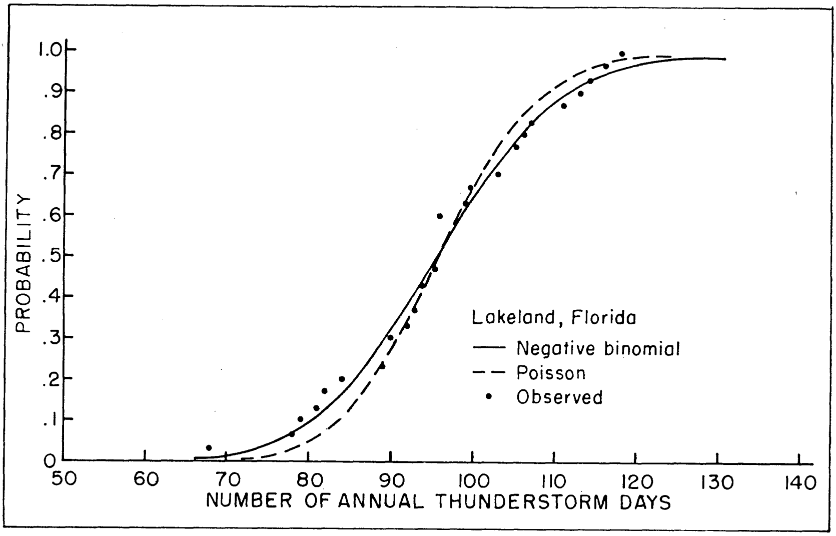


FIG. A. Number of annual thunderstorm days.

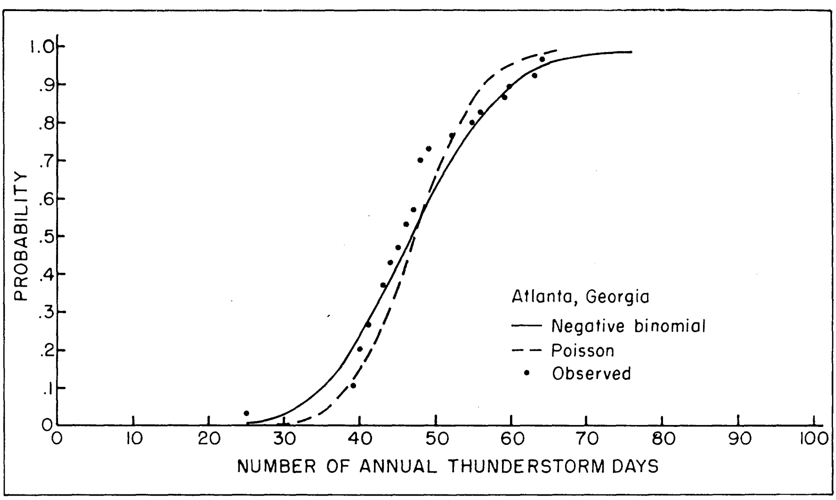


FIG. B. Number of annual thunderstorm days.

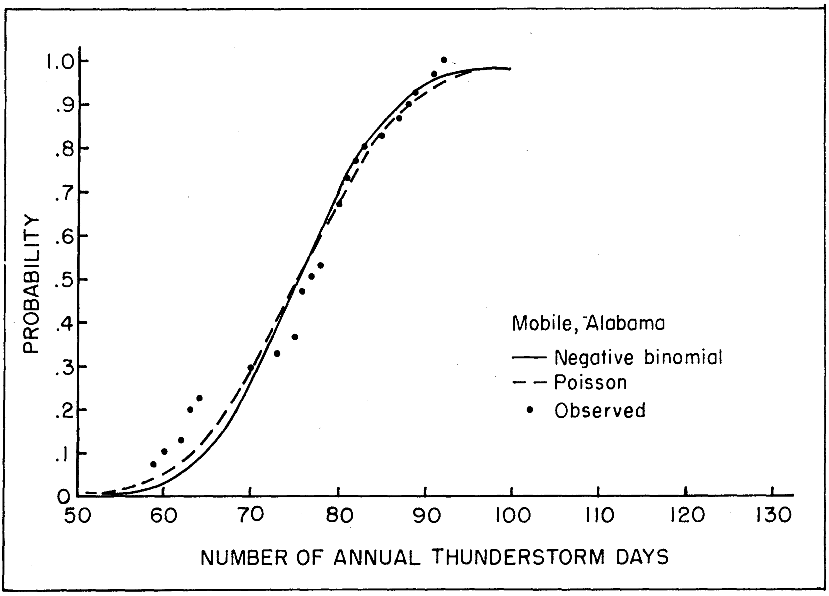
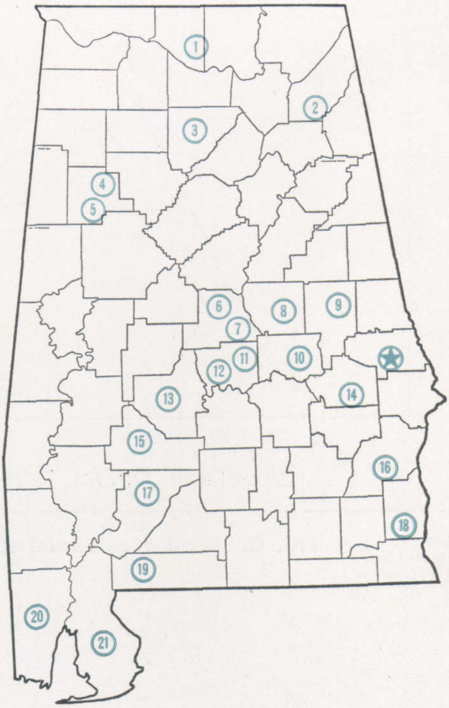


FIG. C. Number of annual thunderstorm days.

Alabama's Agricultural Experiment Station System
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.