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TECHNICAL REPORT
EP-48

A GRAPHIC METHOD FOR ASSESSING HOURLY TEMPERATURE PROBABILITIES

QUARTERMASTER RESEARCH & DEVELOPMENT CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

MARCH 1957 NATICK, MASSACHUSETTS

HEADQUARTERS QUARTERMASTER RESEARCH & DEVELOPMENT COMMAND
OFFICE OF THE COMMANDING GENERAL
NATICK, MASSACHUSETTS

6 March 1957

Major General Kester L. Hastings
The Quartermaster General
Washington 25, D. C.

Dear General Hastings:

This study presents a simple method for predicting the percentage of time that January temperatures at individual weather stations in Alaska will probably be at or below a given level. Although specifically designed for Alaska, this method seems to work as well for some other places, including Southwestern United States. The only information needed to employ the method is: the mean monthly temperatures, the length of record on which the mean monthly temperature is based, and the lowest and highest temperatures recorded during this same period. Of special note is the fact that such data are usually available for weather stations which do not publish their more complete records.

Information on temperature probabilities can be brought to bear on many practical military problems. Questions such as those regarding the amount of fuel likely to be needed for personnel heating, the percentage of time a specific piece of equipment is likely to operate, and the expected operating life of cold-sensitive equipment call for temperature information which the application of the method can provide.

Sincerely yours,

C. G. Calloway
C. G. CALLOWAY
Brigadier General, USA
Commanding

1 Incl
EP-46

HEADQUARTERS QUARTERMASTER RESEARCH & DEVELOPMENT COMMAND
Quartermaster Research & Development Center, US Army
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report
EP-46

A GRAPHIC METHOD FOR ASSESSING HOURLY TEMPERATURE PROBABILITIES

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Geographer

ENVIRONMENTAL ANALYSIS BRANCH

Project Reference:
7-83-01-004B

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Foreword

The percentage of time that temperatures are likely to go above or below certain levels is information of use to the Army in solving problems of design, logistics, and planning. However, in many potential theaters of operations, the only kinds of climatic data which can be obtained are mean and extreme values. If it happens that the distribution of temperatures above and below the mean follows the normal curve, it would be relatively simple to compute from these values the probabilities that any critical temperatures will be reached or exceeded. However, because the hourly distribution of temperature is usually skewed, there is need for a more accurate method for extracting details of the probable distribution of hourly temperatures from generalized data.

In this report a simple graphic method is described for taking generalized data and assessing the percentage of time within a given month when hourly temperatures are likely to be above or below specified levels.

AUSTIN HENSCHEL, Ph. D.
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Environmental Protection Research Division

Approved:

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Contents

	Page
Abstract	iv
1. Introduction	1
2. Construction of hourly temperature probability scales	1
a. An adjusted scale devised for a single station	2
b. An adjusted scale generalized for areal use	7
3. Validation of the adjusted probability scale	7
a. For stations within the selected area	7
b. For stations outside the selected area	11
c. Summaries	11
4. Further studies and refinements	11
5. References	12
Appendix: Some pertinent characteristics of extreme values	15

Abstract

The interpretation of records of weather and climate is of vital concern to Quartermaster Corps interest and activities in every area of the world where records have been accumulated and which is potentially a field of military operation. This report is devoted to the exploration of a short method of assessing January hourly temperature probabilities in a high-latitude continental area.

1. A summary of hourly temperatures at a given station may be achieved through frequency tabulation counts. This is an arduous time-consuming task, and the investigator must have at hand nearly all the details of the record. Rapid results are possible by means of I. B. M. methods, provided that the data have previously been assembled on I. B. M. cards, but card-punching is also time-consuming.

2. The short method explained in this report requires only: (a) the mean daily or monthly temperature, (b) the absolute extremes, and (c) the length of the record. These data are usually given in published temperature summaries.

3. With the data mentioned above at hand, a slide rule, and an adjusted probability scale, the hourly temperature probabilities for a station may be found in a few minutes.

4. As a rule, the probable hourly temperatures on the adjusted scale approximate very closely the results from the frequency tabulation. For practical purposes, the differences usually are not significant.

A GRAPHIC METHOD FOR ASSESSING HOURLY TEMPERATURE PROBABILITIES

1. Introduction

This study is concerned with securing the maximum amount of information from the minimum amount of available data. To put it specifically: How can the percentage distribution of hourly temperatures in January be determined (approximately) at a given station when the only data available are: (1) the coldest hour (extreme minimum), (2) the warmest hour (extreme maximum), (3) the mean (hourly, daily or monthly), and (4) the length of record.

For instance, suppose we know that the mean January temperature at Fairbanks, Alaska is -15.9°F., and that the lowest and highest temperatures ever recorded there in January are -56°F. and 32°F., respectively. The only other information we have is the length of the record: 5 consecutive Januarys. By use of this limited amount of data, can we find the approximate percentage of time the hourly temperature will be -40°F. or lower? This report will develop a method to help answer questions of this type.

The construction of a series of scales on which the hourly temperature probabilities for a given station fall on or near straight lines would meet an urgent need, especially if only simple procedures were involved. If hourly temperature frequencies were normally distributed, they could be shown by a straight line on the well-known normal probability scale. However, the distribution may vary widely from normality, depending on several variable factors.

The present investigation outlines a method of presenting the percentage frequencies of January hourly temperature in one high-latitude continental area (Alaska) by straight lines. Also, it attempts to find out whether a probability scale so designed is usable outside the specific area for which it was constructed.

2. Construction of an hourly temperature probability scale

On the map of Alaska (Fig. 1) are shown eight interior weather stations where January hourly temperature records have been kept for five consecutive years. The essential data for these stations, to be used in constructing an adjusted probability scale, as discussed here, are given in Table I. The "reciprocals" in the last column of the table indicate the percent that one hour is of the whole number of hours in the record. (For example: for Big Delta, 1 hour is 0.0269% of 3718 hours*)

*It is assumed in this illustration that each recorded extreme occurred only once.

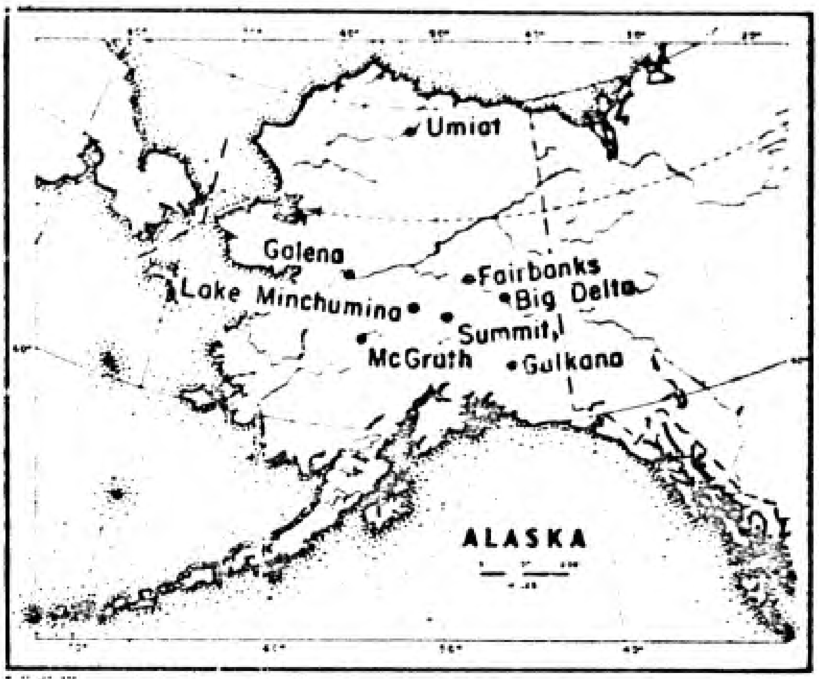

Fig 1. Eight Alaskan interior weather stations

a. An adjusted scale devised for a single station. We will use the data from Big Delta to illustrate the construction of the scale. When the essential data (5 January records, Table I) are entered on a normal probability scale (Fig 2) and straight lines are drawn from the mean (-9.3°F.) to the extreme maximum (33°F. at 0.027%, top of scale) and the extreme minimum (-51°F. at 0.027%, bottom of scale), hourly temperature probabilities may be read at the percentile divisions.* For example, 5% of the time (186 hours) the temperature is shown to be -29°F. or lower.

These probable temperatures would be the correct values if the hourly frequencies were normally distributed. However, a frequency count of these 3718 hourly observations at Big Delta shows this is not so; actually they were distributed as shown in Column 2, Table II.** When these temperatures

*It should be noted that this does not represent a normal distribution. The two straight lines connecting the extremes intersect at the mean.

**The hourly temperature frequencies in Table II were taken from Weather Corporation of America Report, QM Contract DA-44-109-QM-1019, I.B.M. Tabulation, Book 9.

TABLE I: JANUARY CLIMATIC DATA FROM 8 SELECTED STATIONS IN INTERIOR ALASKA

(Hourly temperature record - 1950 to 1954)

STATION	MEAN (°F)	MAXIMUM (°F)	MINIMUM	TOTAL HOURS IN RECORD	RECIPROCAL (%)*
Big Delta	-9.3	33	-51	3718	0.0269
Fairbanks	-15.9	32	-56	3719	0.0269
Galena	-13.9	36	-64	3719	0.0269
Gulkana	-12.7	35	-54	3720	0.0269
Lake Minchumina	-8.7	31	-52	3720	0.0269
McGrath	-13.4	33	-59	3720	0.0269
Summit	-2.2	29	-38	3718	0.0269
Umiat	-21.0	30	-62	3219	0.0311
AVERAGE	-12.1	32.4	-54.5	3657	0.0274

*i.e., the percent that one hour is of the whole number of hours in the record.

TABLE II: JANUARY HOURLY TEMPERATURE FREQUENCIES - EIGHT ALASKAN INTERIOR WEATHER STATIONS* (1950 - 1954, inclusive)

(°F)

% of Hours	Big Delta	Fair-banks	Galena	Gulkana	Lake Minchu-mina	McGrath	Summit	Umiat	Average
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.1		-56	-63	-53	-52	-57	-37	-62	-54.3
0.5	-51	-54	-59	-50	-50	-56	-35	-01	-52.0
1.0	-50	-53	-58	-47	-49	-55	-33	-60	-51.0
5.0	-44	-51	-50	-41	-41	-50	-26	-53	-44.5
10.0	-37	-47	-45	-36	-31	-43	-22	-50	-38.9
20.0	-24	-37	-36	-29	-22	-31	-17	-44	-30.0
30.0	-18	-28	-28	-23	-16	-23	-12	-37	-23.1
40.0	-13	-20	-18	-18	-11	-18	- 7	-32	-17.1
50.0	- 7	-14	-12	-14	- 8	-13	- 3	-25	-12.0
60.0	- 3	- 9	- 7	- 9	- 4	- 9	- 3	-17	-6.9
70.0	2	- 3	- 2	- 4	0	- 3	7	- 9	-1.5
80.0	6	2	5	1	3	4	11	1	4.1
90.0	11	8	13	10	10	11	17	13	11.6
95.0	15	13	18	19	16	19	20	20	17.5
99.0	25	23	27	30	25	28	26	26	26.3
99.5	26	28	29	32	27	30	27	28	28.4
99.9	31	30	31	33	30	32	28	29	30.5

*Data: Alaska, IBM Tabulation Tables, Book No. 9

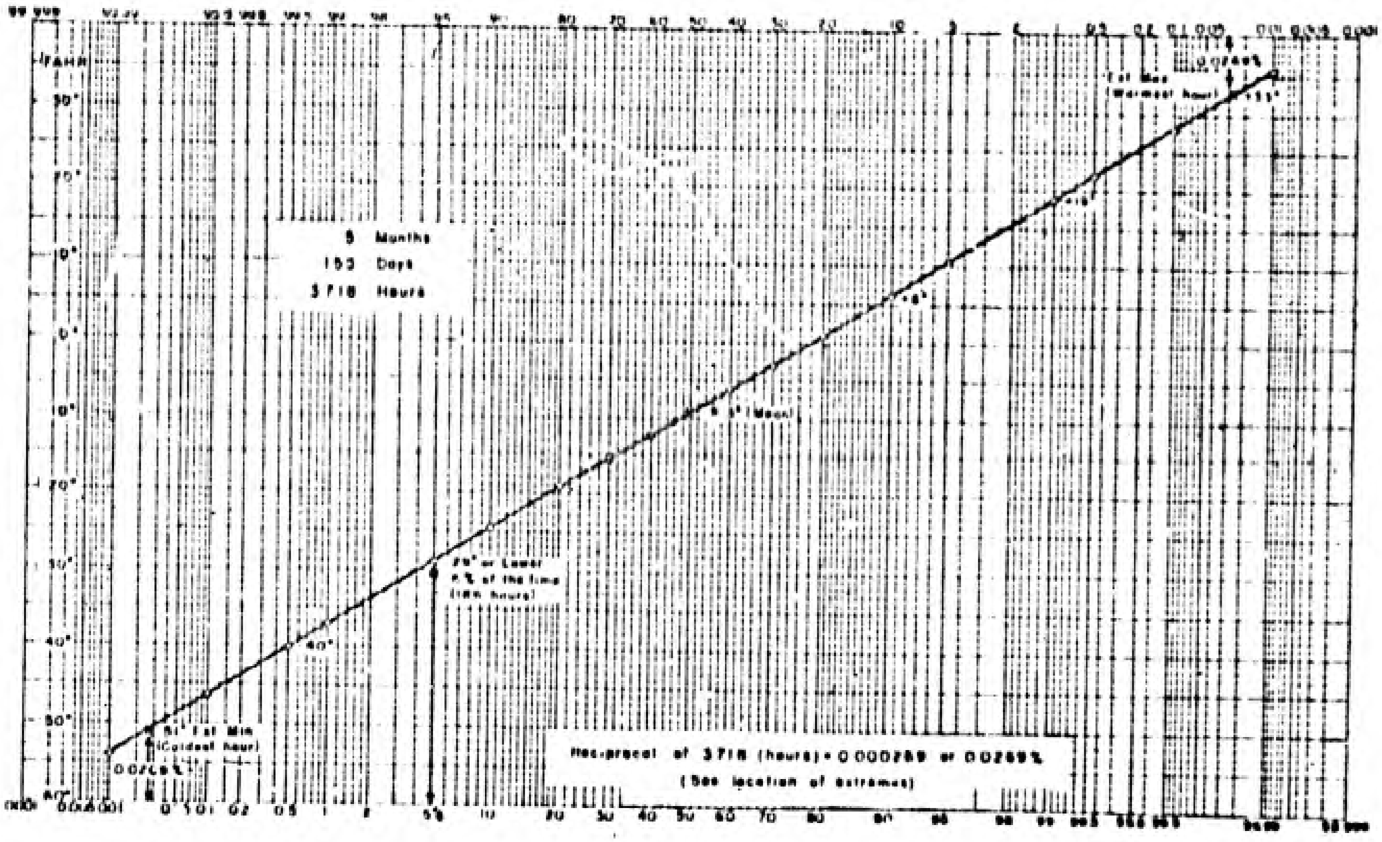

Fig 2. Big Delta, Alaska. 5-January hourly temperature probabilities (1950-54). Normal probability sca!

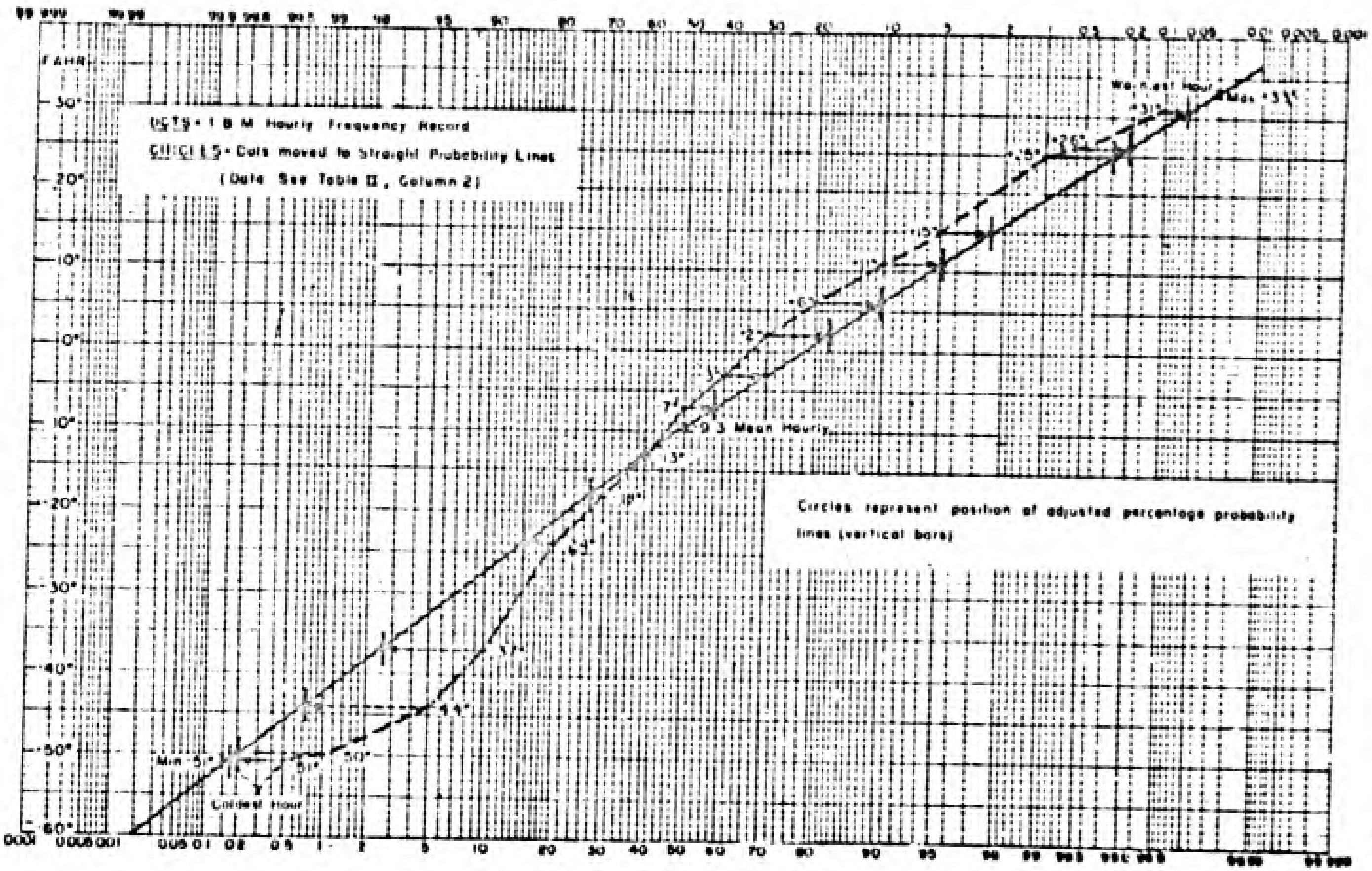

Fig 3. Big Delta, Alaska. Hourly temperatures on straight lines, adjusted from a 5-January frequency distribution

are plotted on a normal probability scale at their associated percentile positions (Fig.3), it may be seen that they are strongly asymmetrical, causing them to lie on an irregularly curved line (dots). The hourly maximum (33°F.) occurred but once, but the hourly minimum (-51°F.) occurred 15 times. Therefore, -51°F. actually falls on 0.21% of the scale instead of 0.026% as indicated in Fig.2.

$$\frac{0.026\% + (15 \times 0.026\%)}{2} = 0.21$$

The observed hourly temperature frequencies on the curved line may be moved horizontally to the two straight lines (small circles and vertical bars). This illustrates the technique employed in constructing a straight-line frequency scale for Big Delta, where hourly temperatures are not normally distributed.

b. An adjusted scale, generalized for areal use. In order to generalize the temperature probability scale for the Alaskan Interior, the temperatures at eight interior stations were averaged as shown in Column 10 of Table II. The straight lines in Figure 4 were drawn on a normal probability scale from the average of the means (-12.1°F.), to the averages of the extremes (-61.5°F. and 32.1°F.). These values are given at the bottom of Table I. The dots in the curved line in Fig. 4 are the plotted positions on the normal probability scale of the percentile average temperatures as shown in Table II, Column 10.

The positions of the percentile averages (see arrows) transferred to the circles on the straight lines, determine the locations of the percentile ordinates when the frequency scale is adjusted. These ordinates are the percentage positions on the adjusted probability scale for hourly temperature probabilities, in January, as a composite of eight stations. When the construction lines are removed from Figure 4, the adjusted hourly probability scale is as shown on Figure 5.

3. Validation of the adjusted probability scale

The chief criterion of validity of the generalized probability scale is the agreement found between the actual frequencies of hourly temperatures at any station and the corresponding frequencies as read from the adjusted probability scale.

a. For stations within the area. How well the actual January frequencies at Big Delta (one of the component stations, Table II, Column 2) fit the adjusted probability scale is shown in Figure 6. The curved line through the actual frequencies (5-January hourly record)* departs from

*"5-January record" as used throughout this report means the record determined for the month of January during a period of five consecutive years.

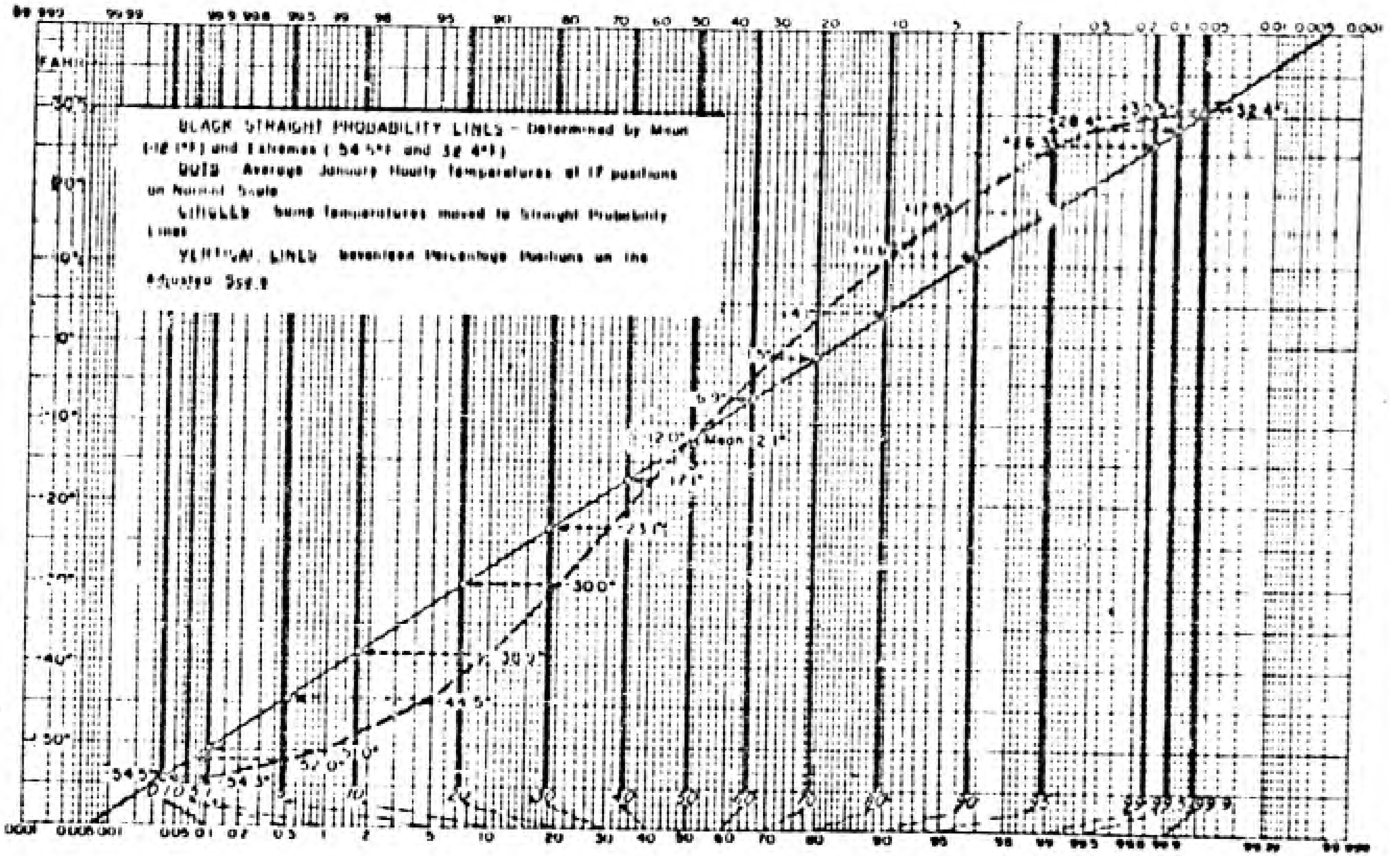

Fig 4. Construction of a straight line probability scale based on the combined records of an 8-station sample (I.B.M. Frequency Data)

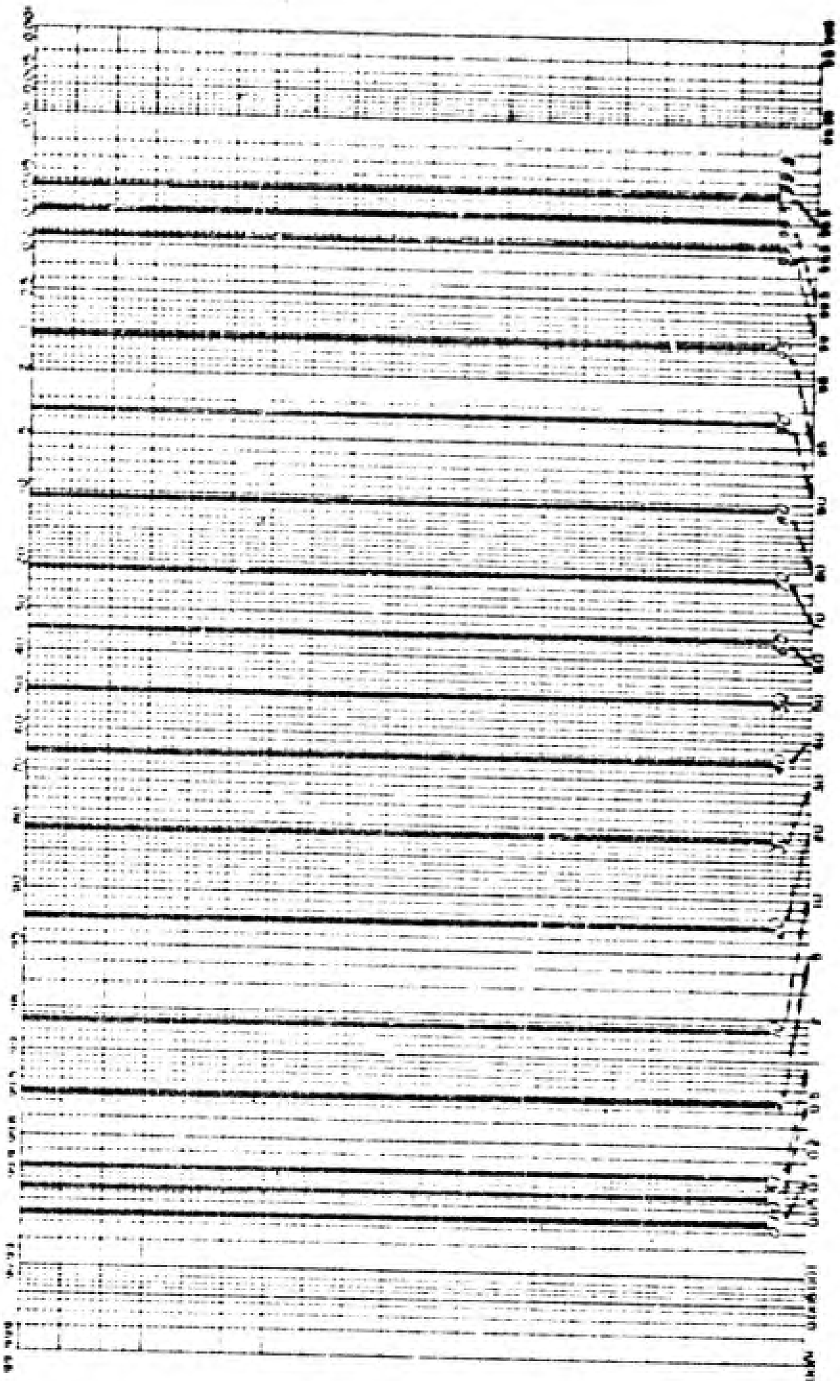

Fig 5. January hourly temperature probability scale, adjusted for Alaskan Interior

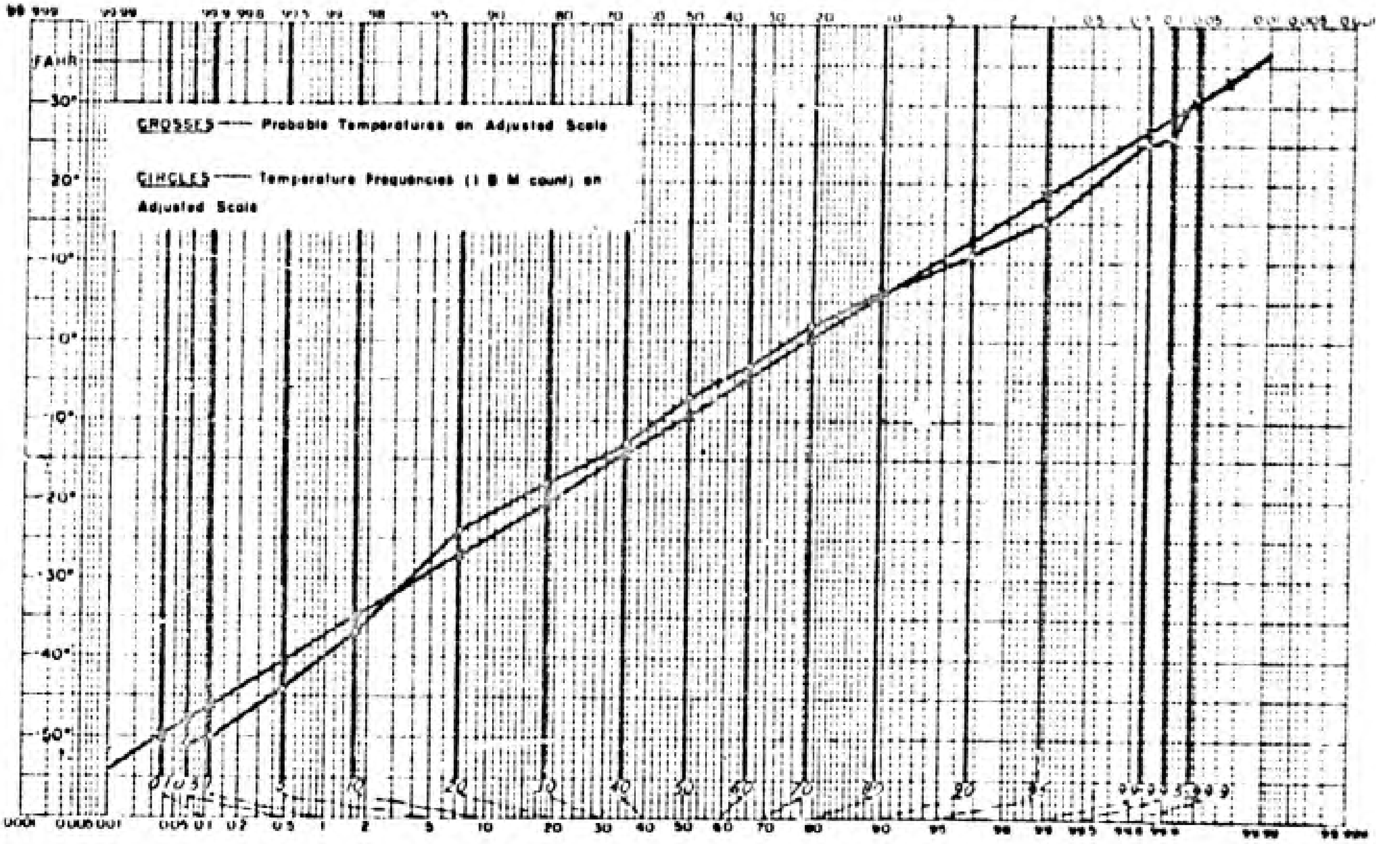

Fig 6. Big Delta, Alaska. Straight line temperature probabilities as related to the 5-January frequencies (3718 hours). See summary in Table III and Figure 3.

the straight probability lines by not more than 3F° or 4F° at any percentile division. For example, it shows at the 10-percentile division that the actual hourly temperature (-37°F. or lower) is 2F° below that of the adjusted scale; at the 90 percentile (11°F. or lower), 2F° below; and at the 50 percentile (-49°F. or lower), 2F° above. (See Table III.)

In a similar manner, one may read from Table III how much the actual temperatures depart from those on the composite adjusted scale at each of 17 percentile divisions for any one of the component stations. It should be noted that in general the most reliable positions on the adjusted scale are in the vicinity of the extremes, as a rule beyond the 1- and 99-percentile divisions. This should be expected because the probability lines are drawn through the extreme highest and lowest observations.

b. For stations outside the area. A limited further survey indicates that the adjusted probability scale herein described may be used in some areas other than the high-latitude continental area for which it was constructed. For example, the same adjusted scale serves for January at Fort Churchill and Anchorage (Table IV) as well as it does in the Alaskan interior. It also fits the frequency distribution of January hourly temperatures in such diverse places as Yuma, Arizona; Amarillo, Texas; Wichita, Kansas; Minot, North Dakota; and Charleston, South Carolina. (See also Table IV.)

c. Summaries

The summaries at the bottom of Table III show that the departure of the actual from the probable is greatest in the vicinity of the 10- and 90- percentile divisions of the adjusted scale. The summaries at the right margins show the contrasts in departure of the actual from the probable at each of the component stations.

Corresponding summaries for the check stations are shown in Table IV.

4. Further studies and refinements

The present study is only the beginning of a search for short-cut methods of assessing probable temperatures. Some features of the continued search are:

a. Set up criteria for the delineating of areas in which a given adjusted probability scale for hourly temperatures will apply. Determine physical relations that account for types of adjustments.

b. Develop a series of probability scales for important climatic regions, and for other seasons than winter.

c. Develop series of probability scales to assess daily minimum and maximum temperatures, corresponding to the hourly probability scale discussed here.

d. Apply this method to other types of climatic data.

5. References

1. Morley, Thomas K. Climatological Atlas of Canada, Department of Transport, Ottawa, Canada, 1953.

2. Spreen, William C. Empirically Determined Distribution of Hourly Temperatures. Journal of Meteorology, 13, pp. 351-355, 1956.

3. Weather Corporation of America (Contract No. DA44-109-QM-1691). Climatic Area Curves. I.B.M. Tabulations, Book 9. Files, Environmental Analysis Branch, QM R&D Center, Natick, Mass., 1955.

Table III. Departure of Observed Temperatures Above or Below Probable Temperatures, as Registered at 17 Percentile Ordinates on the Adjusted Probability Scale

Eight Component Stations (Alaska)	Essential Data: Mean (°F)	Abs. Max. (°F)	Abs. Min. (°F)	No. Hrs. in Period	0.1	0.5	1	5	10	20	30	40	50	60	70	80	90	95	99	99.5	99.9	Difference: Av.	Gr. Pos	Gr. Neg	Least
					Temperature Differences at 17 Percentile Positions																				
Big Delta	-0.3	33	-51	3718		-3	-4	-3	-2	+3	+2	+1	+2	+2	-2	0	-2	-3	-2	-2	+1	-0.9	3	4	0
Fairbanks	-15.9	32	-56	3719	-1	-1	-2	-5	-6	-4	-2	0	+2	+1	+2	0	-2	-3	-4	0	0	-1.6	2	6	0
Galena	-13.9	36	-44	3719	0	+1	0	+1	0	-1	-1	+2	+2	+1	+1	+1	+1	-1	-1	-1	-1	+0.2	2	1	0
Gulkana	-17.9	35	-54	3720	0	0	+2	+2	+2	+1	0	-1	-1	-2	-2	-3	-3	0	+2	0	0	-0.2	2	3	0
L. Minchumina	-8.7	31	-52	3720	-1	-1	-2	0	+4	+5	+4	-3	0	0	0	-2	-2	-2	0	0	+1	+0.4	5	3	0
McGrath	-13.4	33	-59	3720	+1	0	-1	-2	-2	+2	+2	0	+1	-1	0	0	0	+1	+2	+2	+1	+0.3	2	2	0
Summit	-2.2	29	-38	3718	0	0	+3	+2	0	0	-1	-1	+1	+2	+2	+2	+2	+2	+2	+1	+1	+1.1	3	1	0
Umiat	-21.0	30	-62	3719	-1	-2	-3	-1	-4	-6	-5	-6	-4	-2	0	+4	+4	+2	-3	+3	+1	-0.7	7	6	0
Average Differences					-0.2	-0.7	-0.9	-0.7	-1.0	-0.0	0.1	-1.0	+0.4	+0.1	+0.7	+0.2	-0.2	+0.1	-0.5	+0.4	+0.5	Sample Reading: The observed temperature for Big Delta at the 5-percentile ordinate is 3° (-3°), below the probable as registered on the adjusted probability scale. At the 95 percentile the observed temperature is 2° (?) above the probable.			
Greatest Positive Differences					+1	+1	+3	+2	+4	+5	+4	+2	2	2	2	4	4	2	2	3	1				
Greatest Negative Differences					4	5	6	5	6	6	5	6	4	2	2	3	3	3	4	2	1				
Least Differences					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				

TABLE 17: Departure of Observed Temperatures Above or Below Probable Temperatures, as Registered at 17 Percentile Ordinates on the Adjusted Probability Scale

Seven Check Stations	Essential Data: Mean (°F)	Abs. Max. (°F)	Abs. Min. (°F)	No. Hrs. in record	0.1	0.5	1	5	10	20	30	40	50	60	70	80	90	95	99	99.5	99.9	Differences: Av.	Gr. Pos	Gr. Neg	Least
Amarillo, Texas	34.9	80	-4	8171	-3	-2	-1	0	+1	+1	+1	0	0	-2	-2	-3	-3	-3	-2	-1	-1	1.2	+1	-3	0
Anchorage, Alaska	7.1	36	-31	3717	-2	+1	+1	+2	+3	+3	+1	0	0	0	-1	0	-1	0	-1	-2	-2	0.1	-3	-2	0
Charleston, S. C.	51.5	83	19	8160	-2	0	+2	+2	+2	+2	0	0	0	0	0	0	-1	-1	0	0	+1	0.2	+2	-2	0
Churchill, Canada	-13.6	75	-48	2930	-1	-1	-2	-3	-3	-2	-2	-3	0	0	0	-1	-2	-3	-2	-3	-2	1.8	0	-3	0
Minot, No. Dakota	1	45	-34	4464	-3	-3	-3	-2	-1	-2	-3	-2	-2	-2	-2	+2	-2	-2	-3	-3	-1	2.2	0	-3	-1
Wichita, Kansas	30.2	69	-8	8178	-4	-1	0	+1	+1	+1	0	0	0	0	-2	-1	-1	-1	-1	0	+2	0.4	+1	-4	0
Yuma, Arizona	53.6	85	30	4400	-2	-1	-1	0	-1	0	-1	-1	0	-2	-2	-2	-2	-2	-2	-1	0	0.1	0	-2	0
Average Differences					-2.3	-1.0	0.0	0.0	+0.3	+0.4	-0.6	-0.9	-0.3	-0.9	-1.3	-1.3	-1.7	-1.7	-1.6	-1.4	-0.4				
Greatest Positive Differences					0	+1	+2	+2	+3	+3	+1	0	0	0	0	0	0	0	0	0	+2				
Greatest Negative Differences					-4	-3	-3	-3	-3	-2	-3	-3	-2	-2	-2	-2	-3	-3	-3	-3	-2				
Least Differences					1	0	0	0	1	0	0	0	0	0	0	0	1	0	-1	0	0				

SAMPLE READING

The observed temperature for Amarillo, Texas at the 5-percentile ordinate is 1F° (-1F°) below the probable as registered on the adjusted probability scale. At the 10 percentile the observed temperature is 1F° (+1F°) above the probable.

APPENDIX

SOME PERTINENT CHARACTERISTICS OF EXTREME VALUES

In usint this short method of assessing probable hourly temperatures, two characteristics of extreme values require some attention:

a. Frequency of an Extreme Value. The extreme value (maximum or minimum) may occur more than once - varying from one to ten or more (Table V, first column).

TABLE V: Probable Temperature Errors, Registered at Various Percentile Divisions on the Normal Probability Scale, Caused by Multiple Occurrence of Extreme Values for Different Spreads of Absolute Range (40F° to 100F°).

(5-January Record - 3720 Hours)

ABSOLUTE RANGE - MINIMUM TO MAXIMUM

Number of Occurrences of an Extreme	40F°				60F°			
	90%	99%	99.9%	99.99%	90%	99%	99.9%	99.99%
(a) 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(b) 5	0.8	1.3	1.8	2.2	1.1	2.1	2.6	3.0
(c) 10	1.6	2.7	3.5	4.2	2.0	3.9	5.4	6.4
(d) 15	1.8	3.0	3.9	4.6	2.3	4.2	6.0	6.8
	80F°				100F°			
(a) 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(b) 5	1.5	2.3	3.5	4.2	1.8	3.3	4.7	5.5
(c) 10	3.0	5.1	7.3	8.8	3.8	6.7	8.6	10.3
(d) 15	3.3	6.0	7.8	9.4	4.2	7.0	9.0	12.0

The bearing of this variation on the hourly temperature probabilities for an assumed 5-January hourly record is given in Table V. For example, let us assume in line (b) that a given minimum occurs five times instead of once, and that the extreme range is 80F°. The chances are that 90% of the time the error in probable temperature (normal scale) would be about

1.5F° or less; 99% of the time, 2.3F° or less; 99.9% of the time 3.5F° or less, and 99.99% less than 4.2F°.* In a similar manner the error in probable hourly temperatures due to more than one occurrence of this minimum, when the extreme range is 40°, 60°, or 100°, may be read from the table.

The chances for an extreme hourly temperature value occurring more than once is illustrated in Table VI.

TABLE VI: FREQUENCY OF LISTED EXTREME HOURLY TEMPERATURES FOR 76 STATIONS IN THE UNITED STATES

(8184 hours) (APPROXIMATELY 11-JANUARY RECORD)

MAXIMA				MINIMA			
Frequency of Occurrence	Number of Stations	Percentage of Stations	Weighted Frequency	Frequency of Occurrence	Number of Stations	Percentage of Stations	Weighted Frequency
1	43	57	43	1	38	50	38
2	18	24	36	2	16	21	32
3	7	9	21	3	15	19	45
4	6	8	24	4	3	5	12
5	1	1	5	5	2	3	10
6	1	1	6	6	1	1	6
7	0	0	0	7	0	0	0
8	0	0	0	8	0	0	0
9	0	0	0	9	0	0	0
10	0	0	0	10	1	1	10
TOTALS	76	100	135		76	100	153
WEIGHTED FREQUENCY (Average)			1.8	(Average)			2.01

This summary was made from an 11-years January record (8184 hours) at 76 weather stations in the United States.** It should be noted that the average weighted number of occurrences for the extreme maximum is 1.8 times, and for the extreme minimum is 2 times. It seems safe to assume (continued)——

*This can be demonstrated by use of a normal probability scale.
**From data in final report of Contract DA-44-109-QM-1019, Weather Corporation of America (IBM Frequency Count), Books 1 to 7, January 1955.

for plotting purposes that the mean occurrence of extreme temperature is about two times.

b. Isolation of an Extreme Value. The extreme value may be isolated by one to several degrees from the next associated value. How this variation affects the hourly temperature probabilities given by a normal probability scale is shown in Table VII.

TABLE VII: Probable Temperature Errors, Registered at Various Percentile Divisions on the Normal Probability Scale, Caused by Isolation of Extreme Values for Different Spreads of Absolute Range (40F° to 100F°).

(5-January Record - 3720 Hours)

ABSOLUTE RANGE - MINIMUM TO MAXIMUM

Degrees of Isolation		40F°				60F°			
		90%	99%	99.9%	99.99%	90%	99%	99.9%	99.99%
(a)	1	0.8	0.8	0.9	1.5	0.7	0.8	1.1	1.4
(b)	3	1.4	2.3	2.8	3.4	1.3	2.2	2.7	3.3
(c)	5	2.1	3.4	4.9	5.3	2.0	3.3	4.7	5.3
		80F°				100F°			
(a)	1	0.5	0.7	1.0	1.2	0.4	0.6	0.8	1.1
(b)	3	1.2	2.1	2.6	3.2	1.1	2.0	2.5	3.1
(c)	5	1.9	3.2	4.6	5.2	1.7	3.1	4.1	5.1

For example, in line (b) let us assume that the extreme minimum is 3F° below the next lowest temperature in the series, and that the extreme temperature range is 40F°. The chances are that the error in probable temperature at the 90-percentile position will be about 1.4F° or less; 2.3F° or less at the 99-percentile; 2.8F° or less at the 99.9-percentile; and 3.4F° of less at the 99.99-percentile.

A survey of the isolation of extremes of hourly temperatures at 78 weather stations in the United States (W.C.A. Report, Books 1 to 7, 1955) may be summarized as follows:

(a) Extreme maximum temperatures:

3^{o}	of isolation	2%	(2 stations)
2^{o}	" "	2%	(2 stations)
1^{o}	" "	16%	(12 stations)
0^{o}	" "	80%	(62 stations)

(b) Extreme minimum temperatures:

1^{o}	of isolation about	2%	(2 stations)
0^{o}	of " "	98%	(76 stations)

The above tabulation seems to indicate that isolated maxima occur more frequently and with larger intervals than minima do.

It should be noted also that extremes isolated by as much as 3^{o} did not occur among the 78 stations more than two times, and the greatest isolation to be expected 99% of the time is about 2^{o}. Thus, for stations where only a single maximum or minimum is recorded, the best practice might be to assume about one degree of isolation for plotting on a probability scale.

From the foregoing discussion the repetition of extreme values in a given distribution apparently decreases the hazards of greater extremes, and the isolation of extreme values apparently increases the probable hazards. For practical purposes the two (repetition and isolation) cancel each other out. This assumption is critical, since the use of the adjusted probability scale is predicated on the accessibility of only four items in the record (par. 1, of this report).

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