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QUARTERMASTER RESEARCH & ENGINEERING COMMAND
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TECHNICAL REPORT

EP-122

FREQUENCIES AND DURATIONS OF HOURLY TEMPERATURES
FORT GREELY, BIG DELTA, ALASKA

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QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

JANUARY 1960

NATICK, MASSACHUSETTS

QUARTERMASTER STUDIES OF TEMPERATURE FREQUENCIES
AND RELATED CLIMATIC CONDITIONS

EP-2	Frequency and Duration of Low Temperatures at Fort Churchill, Manitoba, Canada	1954
EP-5	Handbook of Big Delta, Alaska, Environment	1955
EP-6	Frequencies of Selected Low Temperatures in Alaska	1955
EP-25	Frequency of Cold-wet Climatic Conditions in the United States	1958
RER-24	Samples of Climatic Frequency Data	1958
EP-122	Frequencies of Temperatures, Fort Greely, Big Delta, Alaska	1960
EP-	Microclimatology of a Subarctic Spruce Forest and a Clearing at Big Delta, Alaska (in preparation)	1960

HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report
EP-122

FREQUENCIES AND DURATIONS OF HOURLY TEMPERATURES

FORT GREELY, BIG DELTA, ALASKA

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Project Reference:
7-83-01-006

January 1960

Foreword

Fort Greely, Big Delta, Alaska, in subarctic, interior Alaska, is the northernmost U.S. Army post. Lying in a region having extremely cold winters, cool summers, and a variety of terrain and vegetation, the area is used extensively for testing and training. The Arctic Test Board, US Continental Army Command (USCONARC), conducts year-round tests of clothing and equipment; and summer and winter courses in survival and tactical operations are given for officers and men at the Mountain and Cold Weather Indoctrination School with Headquarters at Fort Greely.

It is intended that this report provide temperature information which would be more realistic and reliable than that now available and thereby assist test planners in selecting optimum times for scheduling tests.

This report is another in the series of Quartermaster studies dealing with the frequencies and durations of climatic elements, both singly and in combination. Previous studies dealt with low temperatures for Alaska and at Fort Churchill, Manitoba, Canada, and with cold-wet conditions in the United States. Future studies will present the frequencies of temperatures, wind, and cold-wet conditions for the cold regions of North America and Eurasia.

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Abstract

This report presents in detail the frequency and duration of hourly temperatures by months, at Fort Greely, Big Delta, Alaska.

In winter, temperatures at or below -40°F may be expected only 3 percent of the time in December, 8 percent in January, and 4 percent in February. In these same three months, temperatures at or below -25°F can be expected about 12, 17, and 11 percent of the time, respectively. From October through April, temperatures are at freezing (32°F) or below, from 56 percent of the time (April) to 99 percent of the time (January). Temperatures above freezing occur 8 percent of the time or less from November through March, and only 1 percent of the time in January.

In winter, the maximum number of consecutive hours with temperatures at or below -25°F has been 103 hours in November, 248 hours in December, 162 hours in January, and 311 hours in February. The average number of consecutive hours per -25°F cold spell for these four months are 30, 28, 32, and 28 hours, respectively.

In December, January and February, the average longest period of consecutive days per month with minimum temperatures at or below -25°F is 2, 5, and 5, respectively; at or below -40°F , it is 0, 1, and 2, respectively.

In summer, temperatures at or above 68°F occur from May through September, but for only a maximum of 17 percent of the time in the warmest month, July, and a minimum of less than 1 percent of the time in September.

In June, July, and August, the average longest period of consecutive days with maximum temperatures at or above 68°F is 6, 9, and 5 days, respectively; at or above 50°F , it is 25, more than 30, and 24 days, respectively; and at or above 32°F , it is 30, 31, and 31 days, respectively.

FREQUENCIES AND DURATIONS OF HOURLY TEMPERATURES
AT FORT GREELY, BIG DELTA, ALASKA

1. Introduction

The Fort Greely Test Area of the Department of the Army is located in the subarctic interior of Alaska about 110 miles southeast of Fairbanks along the Richardson Highway, between $63^{\circ} 50'$ and $64^{\circ} 10'$ N latitude, and $145^{\circ} 30'$ and $145^{\circ} 50'$ W longitude (Fig. 1). Since the winter of 1948-1949, the U.S. Continental Army Command (USCONARC) and various Technical Services of the United States Army have used this area of approximately 200 square miles for testing items of clothing and equipment intended for use in the Arctic and Subarctic.

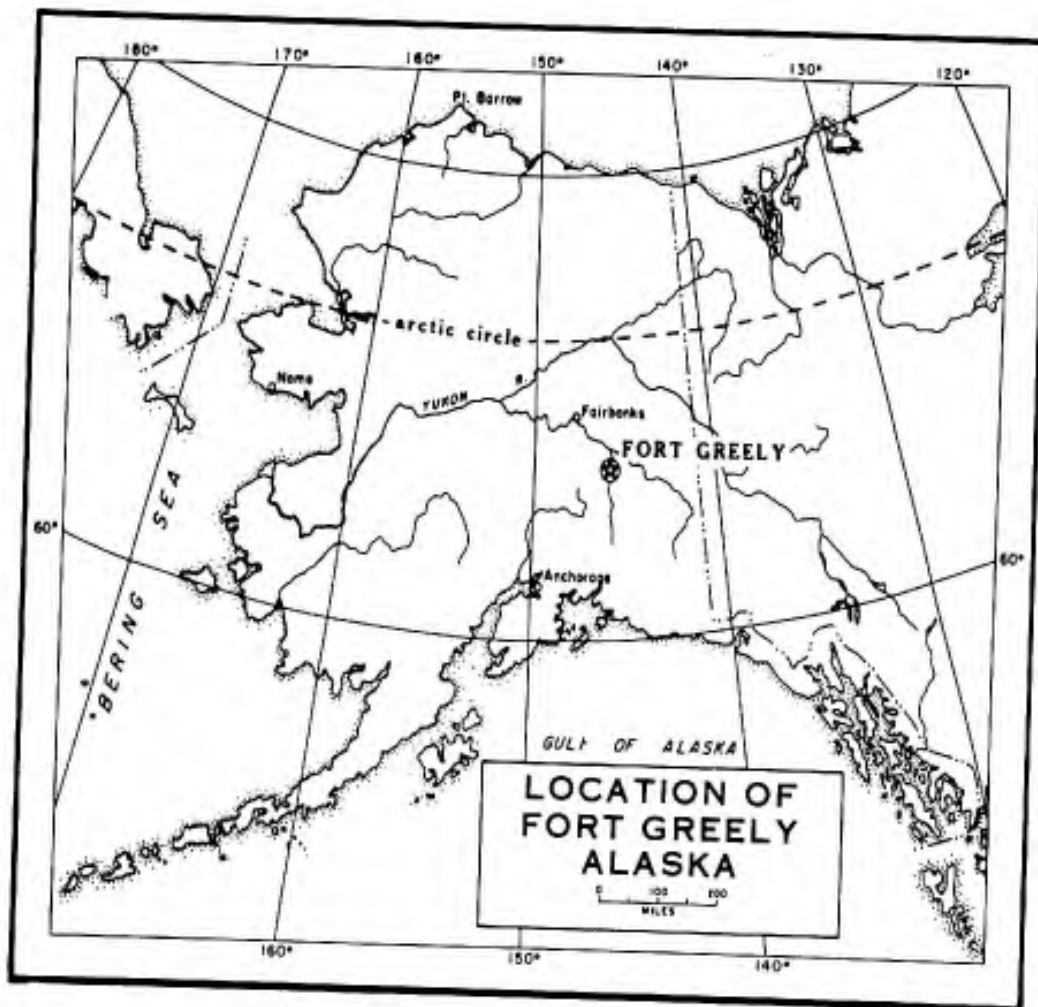


Figure 1

Established as Big Delta Army Post in 1948, the military installation was officially designated and dedicated as Fort Greely during the summer of 1955, thus becoming the U.S. Army's northernmost permanent installation. Fort Greely, in addition to being used as a center for testing and developing cold-weather items of clothing and equipment, is also an arctic and subarctic training and indoctrination center for military personnel. Training in winter and summer operations is provided by qualified instructors of the Army Mountain and Cold Weather Indoctrination School. Each year several hundred officers and noncommissioned officers attend exercises conducted by this school.

The area used for testing military equipment is mainly confined to the land lying south of Delta Junction, where the Alaska Highway joins the Richardson Highway. It is bordered on the west by the Delta River and on the east by the Alaska Highway. To the south, the foothills of the Alaska Range are the limit of operations.

2. Purpose and Scope

The purpose of this study is to provide detailed information pertaining to the frequencies and durations of temperatures, especially low temperatures, in a subarctic area used by the United States Army for testing and training activities. The data are in the form of graphs and tables based on hourly temperatures. They supplement a previous report "Handbook of Big Delta, Alaska, Environment"*, which provides frequencies of daily maximum and minimum, but not of hourly temperatures. These hourly frequency data will provide more useful information than could be provided by daily mean values. They will, for example, provide test personnel with a realistic picture of the temperature stresses actually encountered in the test area.

3. Source and Limitations of Data

Temperature data used in this study are those recorded at the weather station of the Civil Aeronautics Administration, at the Big Delta Airfield. The hourly dry bulb temperatures were provided by the National Weather Records Center, Asheville, North Carolina (U.S. Weather Bureau, 1954). Data are for the period July 1944 through December 1953.

Like most "standard" weather observations, temperature measurements at the CAA weather station should not be considered representative of temperatures throughout the test area. Differences due to varying conditions of topography, vegetation, soil elevation, and slope must be anticipated. This is especially true in winter, when temperatures in the field are often more than 20F° lower, and occasionally 40F° to 50F° lower, than those recorded at the CAA station. For example, on 24 December 1955, at 0800 hours, a difference of 45F° (-4°F compared with -49°F) occurred

*See Reference 3, de Percin et al, 1955.

between two field stations about 10 miles apart in the Big Delta area. At the same time the temperature was -37°F at the CAA station, located about 3 miles from the station recording -49°F . In addition to differences caused by location, differences may sometimes occur between temperatures at the standard level of about 4 1/2 feet and those at or near the ground or snow surface. However, studies conducted at Fort Greely by de Percin (1958) show that, in winter, these differences may not be as large as previously believed. All temperature data used in this study were recorded in a standard instrument shelter, about 4 1/2 feet above the ground surface. When used with data obtained from topoclimatic and microclimatic studies at Fort Greely, these data should provide a reliable indication of temperature conditions to be expected in other parts of the area.

4. Terrain and Vegetation

The terrain and vegetation of the Big Delta area have been described in detail by Péwé (1953, 1955), Holmes and Benninghoff (1957), and de Percin, Falkowski and Miller (1955).

5. Climatic Summary

The climate of the area has been discussed in detail by Fitten (1930), Ehrlich (1953), de Percin, Falkowski, and Miller (1955), Mitchell (1955), Evans (1957), and de Percin (1958), and the information provided below is intended as only a brief résumé.

a. Sunshine and Radiation

The relative coolness of summer in this region is partly offset by the long hours of sunlight. During winter, sunshine and radiation are greatly reduced by the long hours of darkness, low elevation of the sun, and the shadowing effect of high mountains to the south. Long, cold winters and short, cool summers are, therefore, typical of the area. January, the coldest month, has a mean temperature of -5°F ; July, the warmest month, has a mean temperature of 59°F (Fig. 2).

b. Temperature

The annual range of temperature between extremes (i.e., absolute maximum and absolute minimum) is usually from 125°F to 150°F . Although temperatures remain low throughout most of the winter, significant variations are not unusual; temperatures as high as 32°F are not uncommon, and values between 45°F and 50°F have been recorded in December, January, and February.

In summer, the frost-free period is usually 70 to 90 days, a period sufficiently long to allow local residents to grow vegetables. Daily mean maximum, mean, and mean minimum temperatures of each day of the month are shown in Figures 3a and 3b.

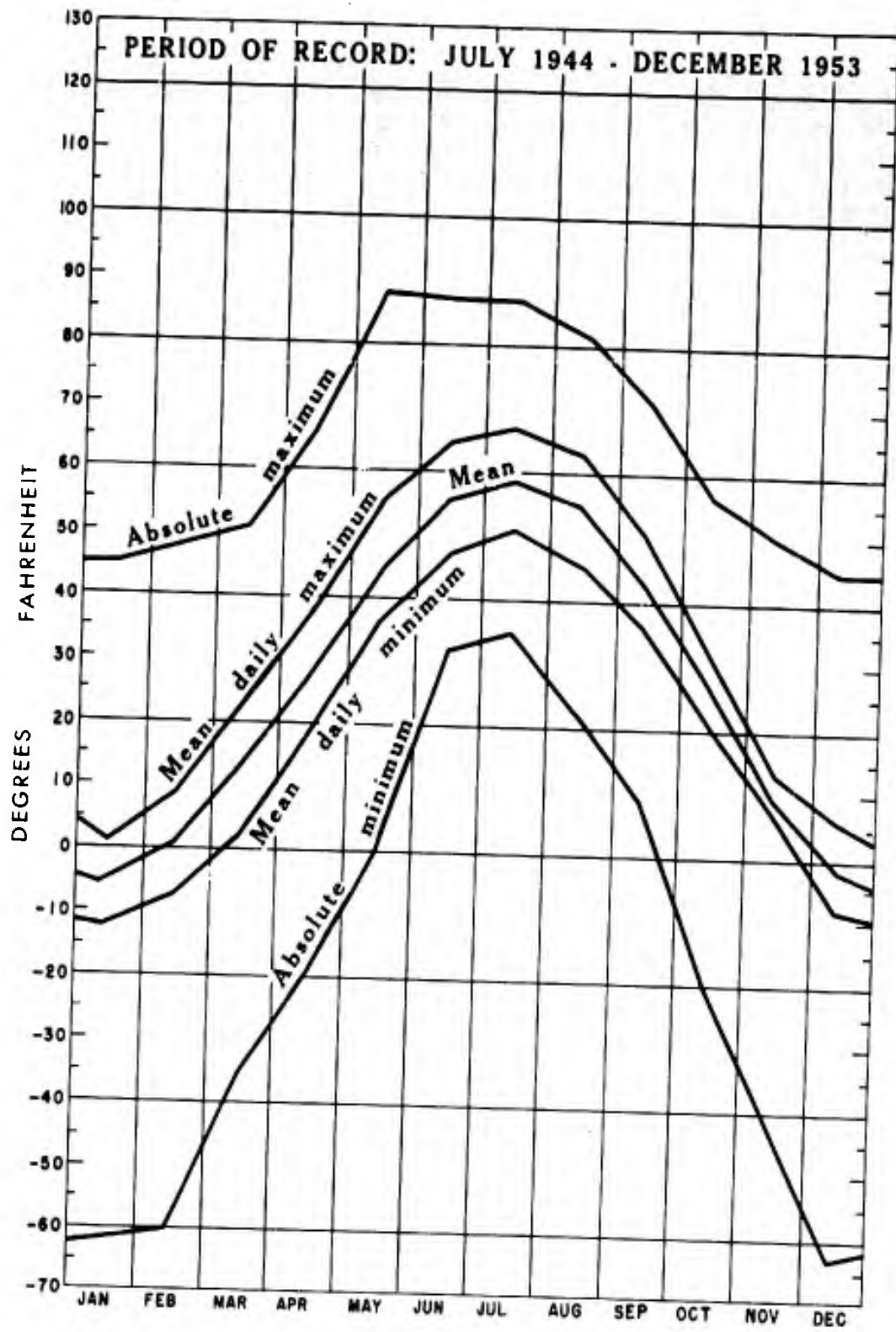


Figure 2. Temperature regime, Fort Greely, Alaska.

c. Precipitation

This area receives less than 12 inches of precipitation each year. Over 9 inches of this total occurs, usually as rain, during the 5-month period, May through September, and over 7 of these 9 inches fall as rain during summer, June, July, and August.

d. Windspeed

Mean windspeeds are between 8 mph (July) and 17 mph (January and February) and the prevailing directions are southwest in summer and east-southeast the rest of the year.

Of great significance is the occurrence of very strong winds during the year. Unlike true "gravity" or "glacier" winds, the strong winds in this area are caused by topographically-induced convergence of the flow of air down the Tanana Valley at times of southeasterly gradient winds aloft (Mitchell, 1955). When they occur, either in winter or in summer, these winds may persist at sustained velocities for several days at a time. During the summer of 1955, from 22 to 24 August and 26 and 27 August, average windspeeds in excess of 25 miles per hour were recorded. Maximum gusts were 45 to 60 mph, and early in the morning of 27 August a windspeed of 70 mph was recorded.

e. Cloudiness

The greatest number of clear days (0 - 3/10 sky cover) occurs in winter and the greatest number of cloudy days (8/10 to 10/10 sky cover) occurs in summer. The clear conditions that exist in winter, combined with a greater frequency of calm or near-calm wind conditions, accentuate the loss of terrestrial radiation from the snow-covered surface and provide an ideal situation for the occurrence of very low temperatures. In summer much of the incoming solar radiation is absorbed or reflected (or both absorbed and reflected) by the cloud cover, and less is probably received than might generally be expected with clear skies.

6. Frequencies of Temperatures

It is usually important for test planners, design engineers, and logistical planners to know how often certain critical temperatures occur during any month. This information is not provided by mean or extreme values, but rather by frequencies. Temperature values here used for computing frequencies and durations (with the exception of 0°F) are those which directly influence the issue of clothing and equipment, or are

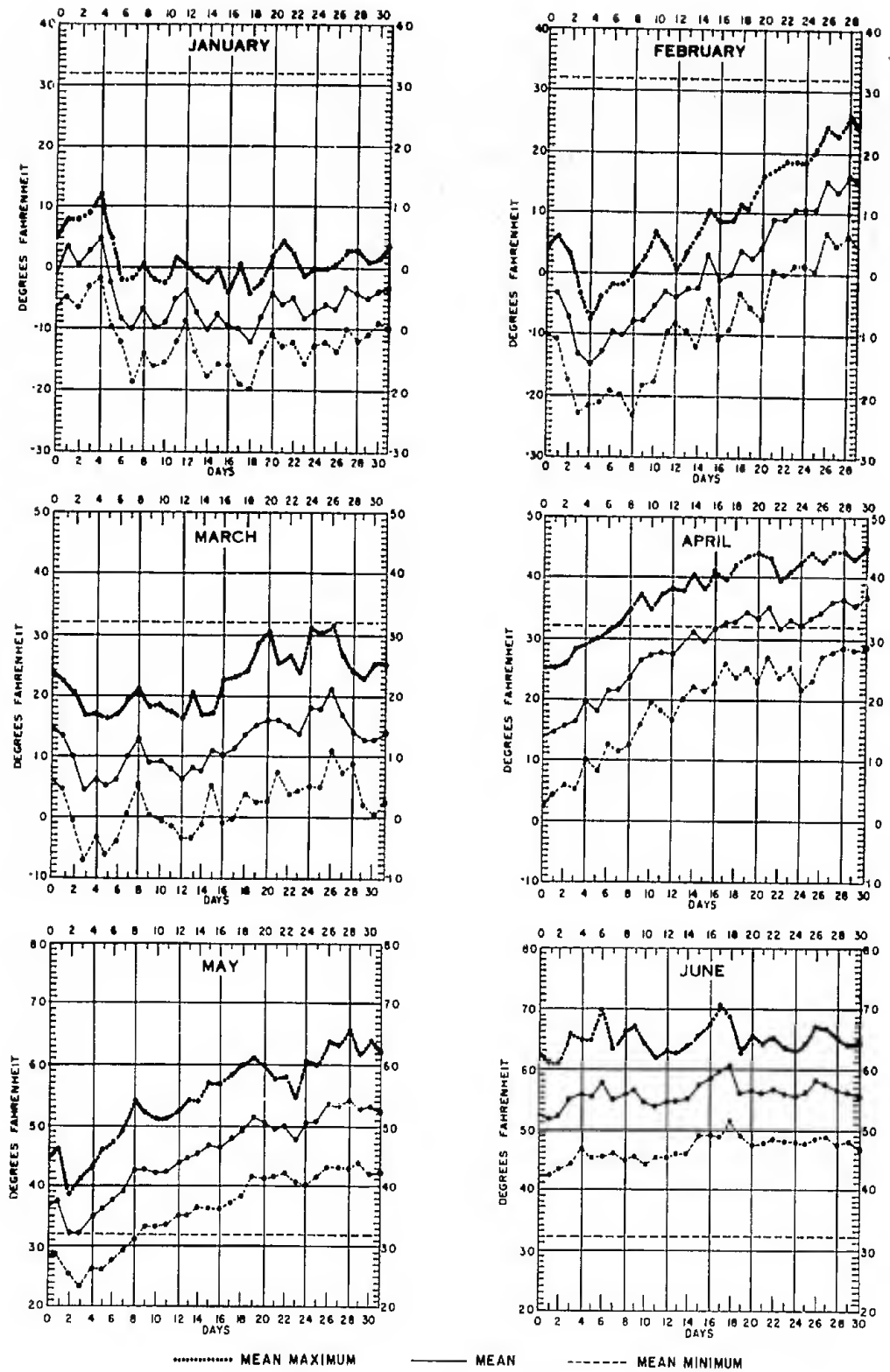
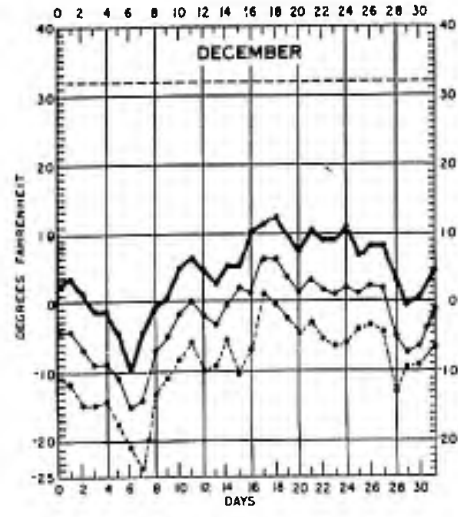
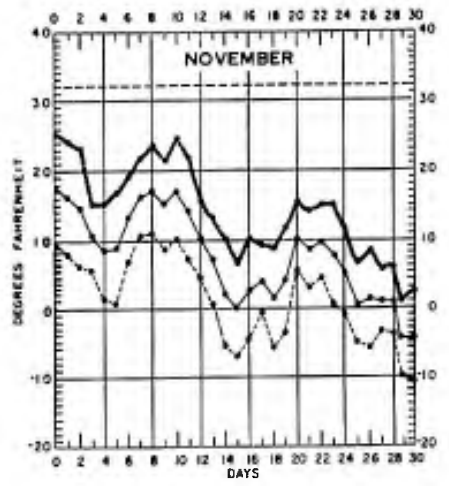
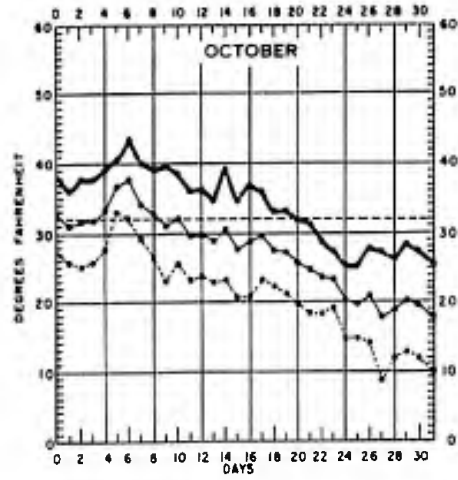
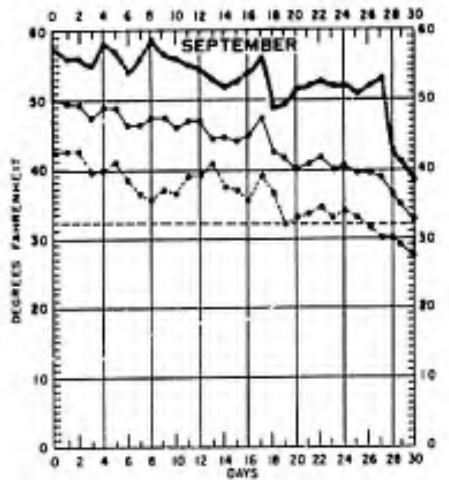
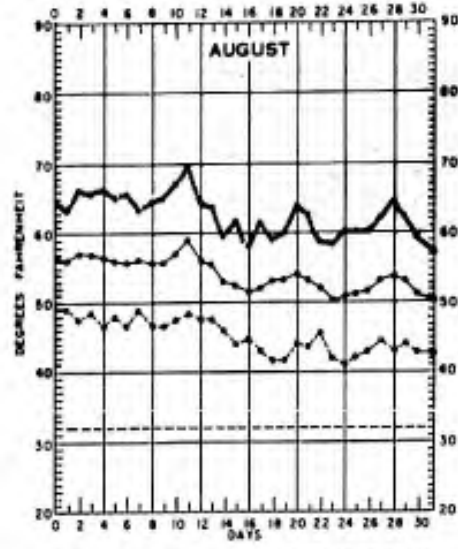
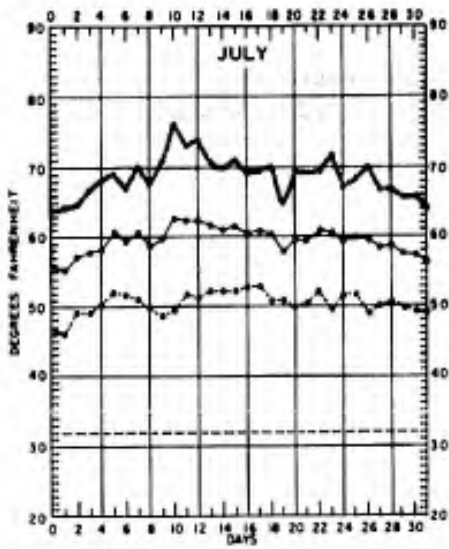


Figure 3. Daily mean maximum, mean and
 Period of record:
 a. January - June



..... MEAN MAXIMUM ——— MEAN - - - - MEAN MINIMUM

mean minimum temperature, Fort Greely, Alaska.
1944 - 1953

b. July - December

specifically mentioned in official publications* containing information of the temperature extremes for which materiel should be designed and in which it should function. These selected temperature values are as follows: 68°F, 50°F, 32°F, 23°F, 14°F, 0°F, -25°F, -40°F, -65°F, and -80°F. Because temperatures of -65°F and -80°F did not occur at Fort Greely, they are not included in the tables or graphs. Data are presented in both tabular and graphic form to facilitate use.

Relative (percentage) and cumulative frequencies of temperature, from the absolute maximum (90°F) to the absolute minimum (-63°F) recorded during the period of record (1944 through 1953) are shown for each month in Figures 4 and 5, and values for the selected temperatures are listed in Table I.

TABLE I

FREQUENCIES (in %) OF HOURLY TEMPERATURES AT OR BELOW SELECTED VALUES AT FORT GREELY, ALASKA

(Period of Record: 1944-1953)

Month	Years	-40°F	-25°F	0°F	14°F	23°F	32°F	50°F	68°F
	Record								
Jan	9	8	17	52	86	95	99	100	100
Feb	9	4	11	45	73	87	96	100	100
Mar	9	0	<1	21	48	73	92	100	100
Apr	9	0	0	3	12	26	56	97	100
May	9	0	0	<0.5	<1	3	11	64	98
Jun	9	0	0	0	0	0	0	28	89
Jul	10	0	0	0	0	0	0	12	83
Aug	10	0	0	0	0	0	<0.5	36	93
Sep	10	0	0	0	<0.5	1	13	75	>99
Oct	10	0	0	2	10	33	70	>99	100
Nov	10	<0.5	4	31	62	83	95	100	100
Dec	10	3	12	50	82	96	98	100	100

Additional information is given in Tables II and III, which show the average number of days per month with maximum temperatures at or above, and minimum temperatures at or below, selected temperature values.

*AR 705-15, Operation of Materiel Under Extreme Conditions of Environment, 14 August 1957, and Military Standard 210A, Climatic Extremes for Military Equipment, 2 August 1957.

TABLE II

AVERAGE NUMBER OF DAYS PER MONTH WITH MINIMUM TEMPERATURES
AT OR BELOW SELECTED VALUES. FORT GREELY, ALASKA

(Period of record: 1944-1953)

Month	Years Record	-40°F	-25°F	0°F	14°F	23°F	32°F	50°F	68°F
Jan*	9	4.1	8.2	19.0	28.6	30.2	30.6	30.6	30.6
Feb	9	2.8	6.1	18.0	24.7	26.9	27.9	28.1	28.1
Mar	9	0	1.6	13.3	24.1	29.1	30.8	31.0	31.0
Apr	9	0	0	3.8	8.3	17.1	25.9	30.0	30.0
May	9	0	0	0.2	0.6	2.6	7.8	30.4	31.0
Jun	9	0	0	0	0	0	0	19.3	30.0
Jul	10	0	0	0	0	0	0	15.4	30.2
Aug	10	0	0	0	0	0.1	0.6	25.5	31.0
Sep**	10	0	0	0	0.4	1.6	9.6	29.4	30.0
Oct**	10	0	0	1.8	7.2	15.3	26.2	29.4	29.4
Nov	10	0.1	3.1	13.8	22.3	27.5	29.9	30.0	30.0
Dec	10	3.4	7.2	21.6	28.2	30.6	31.0	31.0	31.0

* Data missing: 4 days in 1948

** Data missing: one month, Oct 1950, and 14 days, Oct 1945

TABLE III

AVERAGE NUMBER OF DAYS PER MONTH WITH MAXIMUM TEMPERATURES
AT OR ABOVE 32°F, 50°F OR 68°F., FORT GREELY, ALASKA

(Period of record: 1944-1953)

	32°F	50°F	68°F
May	30.1	22.4	1.9
June	30.0	28.6	10.2
July	31.0	30.9	16.2
Aug	31.0	29.0	8.1
Sep	29.0	17.9	0.7

a. Low Temperatures

Examination of these figures and tables reveals that, as might be expected, January is the coldest month. During this month, temperatures at or below -25°F and -40°F * may be expected on the average 17 and 8 percent, respectively, of the hours, temperatures at freezing or below may be expected 99 percent of the time, and over half the time (52 percent) temperatures will be 0°F or lower.

December and February are the next coldest months, temperatures below -25°F and -40°F occurring about 11 to 12 percent of the hours and 3 to 4 percent of the hours, respectively, during both these months.

Freezing temperatures (32°F) or lower may be expected on the average over 90 percent of the time from November through March, and during these same months temperatures will remain below 50°F most of the time.

From Figures 4 and 5 it is seen that the range in temperature is far greater in winter than in summer. From November through March the absolute range in temperature (that is, the difference between the highest and lowest temperature recorded in each month during the period of record) is at least 85°F , and during December, January and February, this range is over 100°F . This implies greater variability of temperature in winter than in summer and, in fact, this is stated in a report by Anderson (1955) which shows that Fort Greely lies in the area of North America having the largest standard deviation of temperature in North America, 10°F to 12°F , in January. This compares with a standard deviation of only 2°F to 4°F for July.

In summer (June through August), freezing temperatures seldom occur, and temperatures at or below 50°F may be expected only 12 percent of the time during July, the warmest month. Temperatures of 68°F or lower, however, may be expected over 80 percent of the time in all summer months, indicating the coolness of the summer days.

Table II gives the average number of days each month that minimum temperatures are below selected temperature values. In winter, December through February, minimum temperatures -25°F or below may be expected to occur on the average of 6 to 8 days, and those of -40°F or below, about 3 to 4 days during each month. Minimum temperatures will be 32°F or below more than 26 days each month from October through April.

*Throughout this report the phrase "at or below -25°F " may be written "below -25°F ", for both brevity and emphasis. Similarly, "at or above 68°F " may be written "above 68°F ". In such cases the figure (-25 or 68) is understood to be within the specified range.

In summer, minimum temperatures of freezing or below occur only infrequently in August, but occur nearly 8 days in May and nearly 10 days in September. Minimum temperatures are 50°F or below for about 19 days in June, 15 days in July, and 26 days in August, and during nearly all summer days minimum temperatures are below 68°F.

b. High Temperatures

Table III gives the average number of days each month that maximum temperatures are above selected temperature values. During the warm months (May through September) maximum temperatures are above freezing during all days of the month, and during June, July and August they are above 50°F most days of the month (29 to 31). Maximum temperatures are above 68°F about 2 days in May, 10 days in June, 16 days in July, 8 days in August, and only 1 day in September. These figures show the rapid warming in the spring and cooling in the fall. In spring, warming is retarded by the snow cover which may persist until the middle of May. In the fall, cooling is accentuated by the frequent snowfall and resulting snow cover, and the eventual formation of a permanent snow cover.

7. Durations of Temperatures

In addition to knowing how often certain temperatures may occur during any month or season (as shown by frequency data), it is also important to know for how long a period - that is, for how many consecutive hours or days (or both) - critical temperatures may occur.

a. Consecutive Hours at Minimum Temperatures

Table IV shows the number of consecutive hours per cold spell in each month with temperatures below -25°F and -40°F*. This table shows that in January, the coldest month, temperatures have remained below -25°F for as long as 162 consecutive hours, but for the average cold spell, they remain below -25°F for only 32 hours.

* Where the number of consecutive hours overlapped, from one month to the next, all hours were included in that month having the greatest number of the hours. Where the number of consecutive hours in each month were equal, the hours were added to the month during which the cold spell started.

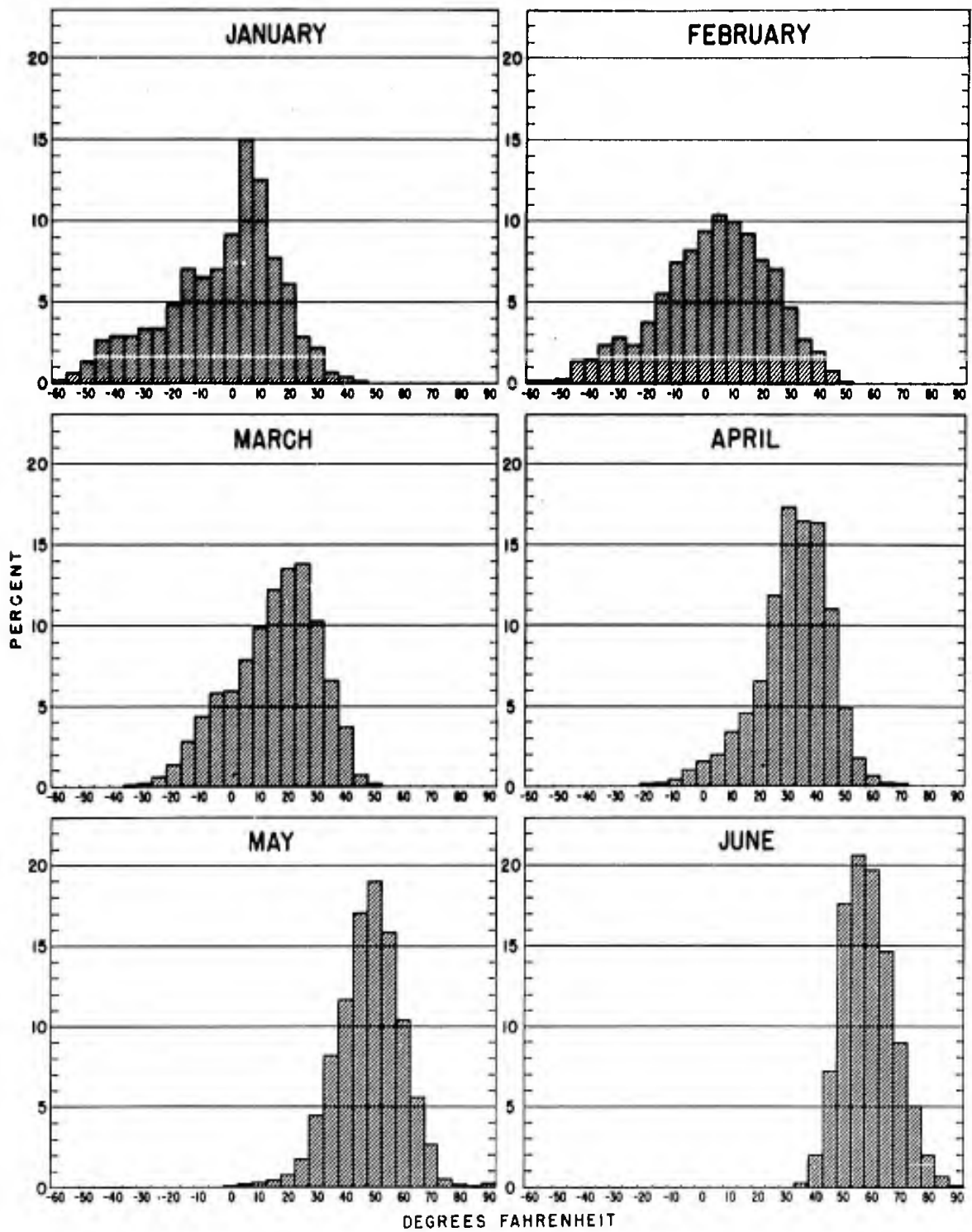
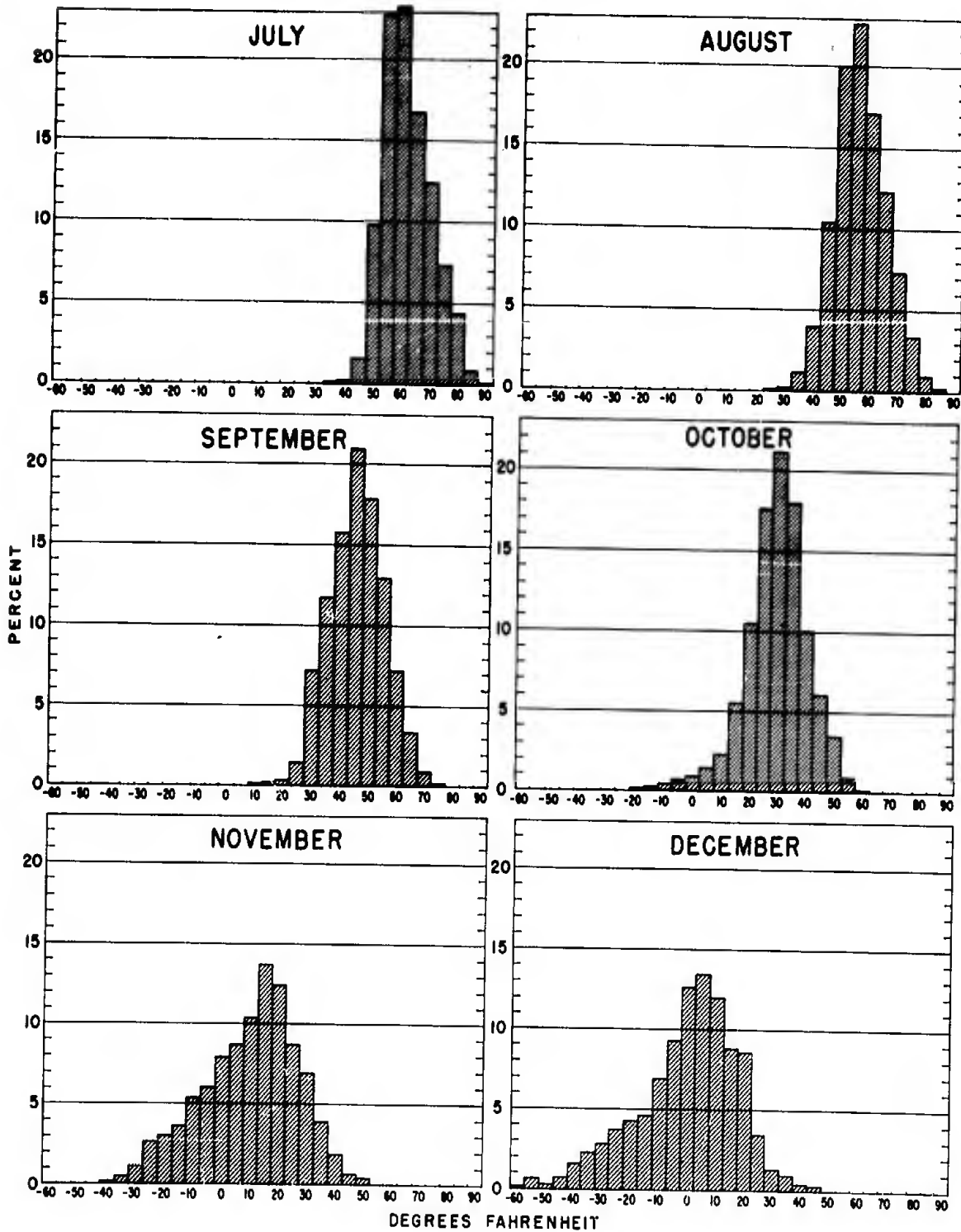


Figure 4. Frequencies of hourly temperatures,
 Period of record:
 a. January - June



Fort Greely, Alaska.
1944 - 1953

b. July - December

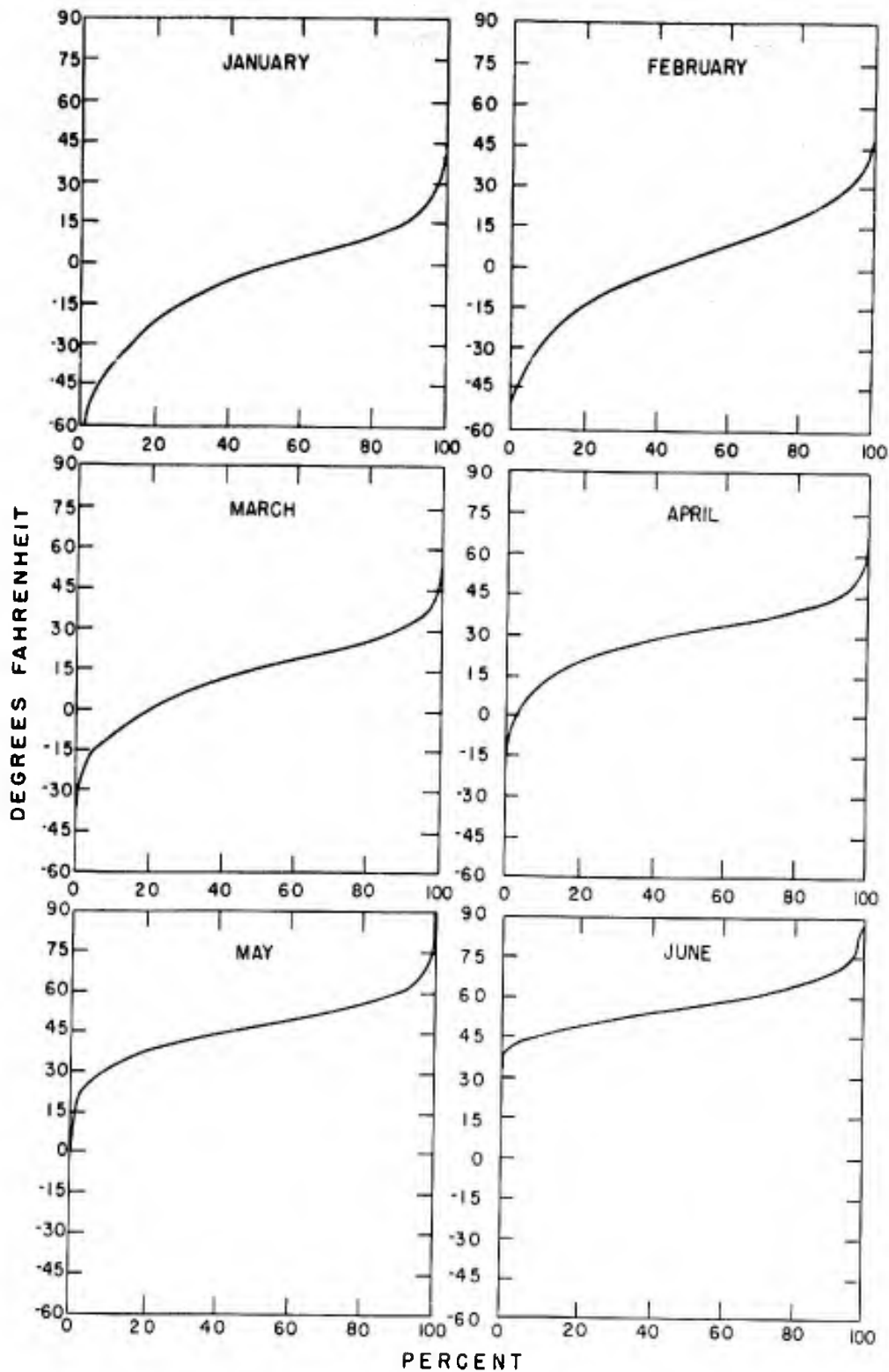
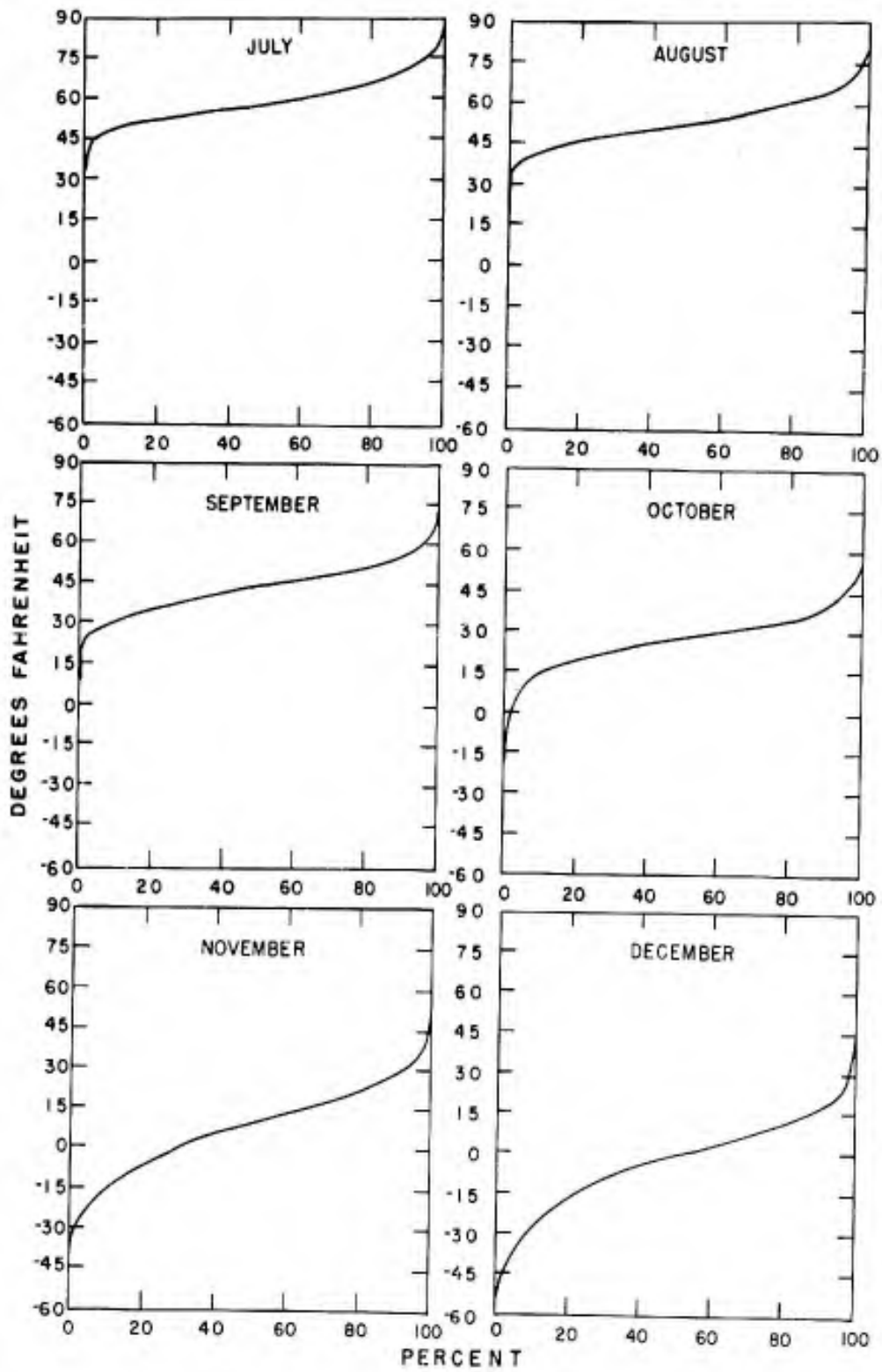


Figure 5. Cumulative frequencies
 Period of record:

a. January - June



of hourly temperatures, Fort Greely, Alaska.
 July 1944 - December 1953

b. July - December

TABLE IV

NUMBER OF CONSECUTIVE HOURS PER COLD SPELL WITH TEMPERATURES
AT OR BELOW -25°F AND -40°F , FORT GREELY, ALASKA

(Period of record: 1944-1953)

Month	Consecutive hours per cold spell:		Mean number of cold spells:	
	Longest*	Average*	Total	Of avg. dur.**
<u>Below -25°F</u>				
Jan	162	32	3	1
Feb	311	28	3	< 0.5
Mar	12	6	1	< 0.5
Apr	0	0	0	0
May	0	0	0	0
Jun	0	0	0	0
Jul	0	0	0	0
Aug	0	0	0	0
Sep	0	0	0	0
Oct	0	0	0	0
Nov	103	30	2	< 1
Dec	248	28	3.1	< 1
<u>Below -40°F</u>				
Jan	75	17	3	1
Feb	19	11	2	1
Mar	0	0	0	0
Apr	0	0	0	0
May	0	0	0	0
Jun	0	0	0	0
Jul	0	0	0	0
Aug	0	0	0	0
Sep	0	0	0	0
Oct	0	0	0	0
Nov	3	3	< 0.5	< 0.5
Dec	84	13	2	< 0.5

*Longest: greatest number of consecutive hours of cold spell

Average: average number of consecutive hours per cold spell

**i.e., the mean number of cold spells which were of average duration (Column No. 2).

An interesting feature of this table is the value given for February. Although January is the coldest month, the greatest number of consecutive hours with temperatures at or below -25°F is nearly twice as great in February as in January (311 compared with 162 hours) for the 9-year period of record. This is possibly caused by a greater frequency of strong winds in January than in February; these winds destroy the surface inversion caused by extreme radiational cooling. The average length of cold spell for this temperature (-25°F), however, is smaller in February than in January (28 compared with 32 hours). On the other hand, the greatest number of consecutive hours below -40°F is greater for January than for February (75 as compared to 19 hours). Cold spells with temperatures at or below -40°F do not generally have a long duration, the average lasting about 13 hours in December, 17 hours in January, and 11 hours in February. There have been periods, however, with temperatures -40°F or below, lasting over 3 days in both December (84 hours), and January (75 hours).

b. Consecutive Days at Minimum Temperatures

The average longest period of consecutive days per month with minimum temperatures at or below the selected values is given in Table V. This table shows that on almost all days of the year minimum temperatures will usually be below 68°F , and from September through May, minimum temperatures will usually be below 50°F .

During the colder months, October through March, minimum temperatures of 32°F and below can be expected on most days of the month. In January and February, periods of 10 to 12 consecutive days may be expected when minimum temperatures will not rise above 0°F , and in these same two months, periods of 5 consecutive days may be expected during which the minimum temperatures each day will not be above -25°F .

c. Consecutive Days at Maximum Temperatures

Table VI shows the average longest period of consecutive days with maximum temperatures at or above the specified values, 32°F , 50°F , and 68°F . Again it is seen that there have been times when nearly all the days of each month had maximum temperatures at or above freezing. May and September, in fact, are the only months in which all days did not have maxima at or above freezing during at least 1 of the 9 years of record. The average greatest number of consecutive days with maximum temperatures at or above 50°F varies from a minimum number of about 12 days in September to a maximum of almost 31 days in July, the warmest month. The coolness of summer is reflected in the values given for 68°F . On the average, only about 9 consecutive days can be expected to have maximum temperatures at or above 68°F during the warmest month, July. For June and August, the average number of consecutive days is 6 and 5,

TABLE V

AVERAGE LONGEST PERIOD OF CONSECUTIVE DAYS PER MONTH WITH MINIMUM
TEMPERATURES AT OR BELOW SPECIFIED LIMITS*
FORT GREELY, ALASKA

(Period of Record: 1944-1953)

Month	-40°F	-25°F	0°F	14°F	23°F	32°F	50°F	68°F
Jan**	1	5	10	21	30	>30	>30	>30
Feb	2	5	12	21	24	26	28	28
Mar	0	<1	8	13	26	28	31	31
Apr	0	0	2	6	11	18	30	30
May	0	0	<0.5	<1	2	7	30	31
Jun	0	0	0	0	0	0	14	30
Jul	0	0	0	0	0	0	6	31
Aug	0	0	0	0	0	<1	17	31
Sep	0	0	0	<0.5	<1	4	28	30
Oct***	0	0	1	4	10	22	29	29
Nov	0	2	9	13	24	29	30	30
Dec	0	2	4	22	29	31	31	31

* Computed by taking the average of the longest period that occurred during each month for the 9 years of record. For example, for 32°F for May, 6.6 days is the average of the longest period that occurred during each of 9 Mays.

** Data missing: 1 days in 1948.

*** Data missing: one month, October 1950, and 14 days, October 1945.

TABLE VI

AVERAGE LONGEST PERIOD OF CONSECUTIVE DAYS PER MONTH WITH
MAXIMUM TEMPERATURES AT OR ABOVE 32°F, 50°F AND 68°F
FORT GREELY, ALASKA

(Period of Record: 1944-1953)

	32°F	50°F	68°F
May	30	17	2
Jun	30	25	6
Jul	31	30	9
Aug	31	24	5
Sep	27	12	<0.5

respectively, and for May and September even 2 consecutive days cannot, on the average, be expected to have maximum temperatures greater than 68°F.

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