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USE OF CLIMATOLOGICAL AND METEOROLOGICAL DATA IN THE PLANNING AND EXECUTION OF NATIONAL GEODETIC SURVEY FIELD OPERATIONS

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ABSTRACT. This study was initiated because of increased interest in the possible applications of available climatological and meteorological data to National Geodetic Survey field operations. The availability, pertinence, uses, and procedures for use of these data are described. Both climatic records and weather forecasts are considered.

I. INTRODUCTION

The Program Planning Unit of the National Geodetic Survey (NGS) is the office responsible for planning field operations. Historically, the coordination of time and place for field observations has been governed by any combination of the following factors: location where observations are desired; time considerations, including length of job and when it must be completed; status of the operational budget; available manpower; and, in a very general sense, the climatology. Although considerations are given to past weather experiences in specific areas, current use of climatology in the planning of project areas is broad in that only latitudinal and seasonal changes are recognized. Little has been done with climatic information for specific localities.

A. The Importance of Climate and Weather

Weather, the immediate state of the atmosphere, and climate, the long-time average condition of the atmosphere, together exert perhaps the greatest single influence on human activities that depend on environmental conditions. Climatic records, analyses of average weather conditions at any given location over extended periods--preferably 30 years or longer--reveal the mean atmospheric conditions for that given location or area for a month, a season, or a year. Planning a field operation without consulting climatological records can lead to unforeseen delays caused by unfavorable weather. For example, if an operation is sensitive to overcast sky conditions, the climatic record for the location of the operation can tell the planner the kind of sky cover he can expect season by season. If the record shows overcast skies 60% of the time during winter and spring, the planner can either select summer or autumn for the operation or, if the operation must be carried out during a less favorable season, he at least knows the risk factor involved.

Unfavorable weather affected NGS field operations heavily during Fiscal Year 1975. Approximately 3,100 man days of scheduled work were delayed or lost,[1] at the cost of wasted effort and man hours, and fruitless expenditures of fuel and funds.

It is because of their influence on weather-dependent activities that climatic conditions are continuously studied and analyzed. Climate and weather must constantly be taken into consideration by both government and industry, if smooth operations are to be achieved.

B. Basic Types of Field Operations

Seven distinct categories of NGS operations are currently carried out in the field: reconnaissance, horizontal control, vertical control, astronomy, gravity, satellite tracking, and calibration base line measurement. Of the seven, five may be adversely affected by unfavorable atmospheric conditions: reconnaissance, horizontal control, vertical control, astronomy, and calibration base line measurement. Atmospheric conditions will affect both reconnaissance and calibration base line measurement, but reconnaissance can usually incorporate adverse weather into the schedule of operations, eliminating much of the loss in productivity which might occur otherwise. Calibration base line measurement procedures are similar to those of horizontal control, the only difference being that visibilities of approximately one mile are sufficient for base line observations while visibilities of 7 miles are required for horizontal control. For this reason, calibration base line measurement will hereafter be treated the same as horizontal control.

Gravity and satellite tracking employ methods and instrumentation enabling them to work, to a large degree, in or around atmospheric conditions. They are rarely inconvenienced, and seldom are there significant delays or losses in work because of weather.

Horizontal control surveys in the field are primarily directed toward determining horizontal positions of selected points on the Earth's surface. The party can be divided into two components, the builders and the observers. The building party erects

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[1] Computed from "Field Party Monthly Report and Journals."

and dismantles towers during daylight hours, and sets the horizontal control marks at points to be positioned. The towers serve as observation platforms, permitting unobstructed views to other stations. The observing teams occupy the observation platforms (i.e., towers or stands) in twilight or darkness, and measure and record directions and distances to other stations.

Vertical control surveys are procedures for obtaining elevations above sea level. The party consists of observers and bench mark setters. Setters physically mark points for which elevations are to be determined. Observers measure the elevation difference between points using precise leveling procedures and equipment. Most of the work is performed outdoors at ground level during daylight hours.

Astronomy in the NGS is a program for stellar observations which are used to provide checks and orientation for the horizontal network. Personnel observe and record the directions of selected stars with an astronomic theodolite. The work is done outdoors at ground level in darkness.

C. Meteorological Conditions Which Can Adversely Affect Field Operations

It has already been determined that three categories of NGS field operations are largely dependent on favorable atmospheric conditions for successful completion of work schedules. Although severe weather (i.e., blizzards, tornadoes, etc.) can interrupt field operations of all types, significant weather-related problems are encountered mainly in horizontal control, vertical control, and astronomy programs. These problems are the result of many meteorological factors acting as a whole to create what is generally known as "adverse weather." To study or plan for adverse weather, one must first identify the individual elements which, together, compose it. These elements will differ somewhat depending on the type of operation involved.

Horizontal Control Parties

Successful tower building, the first step in horizontal control, is largely dependent on precipitation, temperature, and wind conditions. Precipitation and condensation of all types can disrupt tower building. The problem lies mainly in slippery footing on wet or icy metal surfaces. It does not take much moisture to dampen a steel frame; as little as 0.02 inch of precipitation per hour is sufficient to halt construction. Condensation on the framework, usually associated with fog or high relative humidities after dark, can create the same effect as precipitation: a wet, dangerously slippery metal surface. Both of these conditions can cause delays. During periods of showery weather, building may only be delayed temporarily. Between periods of precipitation, the tower may dry off, allowing some work to progress. Showery weather, more common in the warmer months, is frequently accompanied by lightning. Thunderstorms, with their heavy precipitation, lightning, and gusty winds, can make for hazardous conditions for workers on high metal towers. Because of the typically short duration of these storms, however, the danger is limited to fairly short time periods. It is lengthy, continuous precipitation that causes large scale interruptions. During continuous precipitation, totals may be small, but metallic surfaces stay wet in the moist, cloudy environment, and operations must be halted. The duration and frequency of precipitation are most important, not the total amount.

Icy weather conditions, identified by periods of freezing rain, sleet, or snow, are extremely hazardous for tower construction. Snow also can limit access to the area where construction is planned. Therefore, wintertime operations should be scheduled only when unavoidable in areas with high frequencies of cold, wet, or snowy weather.

The effects of temperature on field operations are limited primarily to how temperature extremes affect the ability of people to function effectively. Various combinations of temperature and humidity, or temperature and wind, produce Effective Temperatures[2] or wind-chill[3] equivalent temperatures (fig. 1) that can seriously affect the ability to work. The Temperature-Humidity Index, a recent modification of the Effective Temperature index, may be computed from one of the following equations:

$$THI = 0.4\ (t_d + t_w) + 15$$

$$THI = 0.55\ t_d + 0.2\ t_{dp} + 17.5$$

$$THI = t_d - [(0.55 - 0.55RH)(t_d - 58)]$$

where

t_d = dry bulb temperature (°F)
t_w = wet bulb temperature (°F)
t_{dp} = dewpoint temperature (°F)
RH = relative humidity.

[2]An index of the degree of warmth experienced by the body on exposure to different combinations of temperature, humidity, and air movement.

[3]Cooling effect (rate of heat loss from a body) resulting from any combination of temperature and wind.

Wind speed (mi/h)	45	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40	−45
4	45	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40	−45
5	43	37	32	27	22	16	11	6	0	−5	−10	−15	−21	−26	−31	−36	−42	−47	−52
10	34	26	22	16	10	3	−3	−9	−15	−22	−27	−34	−40	−46	−52	−58	−64	−71	−77
15	29	23	16	9	2	−5	−11	−18	−25	−31	−38	−45	−51	−58	−65	−72	−78	−85	−92
20	26	19	12	4	−3	−10	−17	−24	−31	−39	−46	−53	−60	−67	−74	−81	−88	−95	−103
25	23	16	8	1	−7	−15	−22	−29	−36	−44	−51	−59	−66	−74	−81	−88	−96	−103	−110
30	21	13	6	−2	−10	−18	−25	−33	−41	−49	−56	−64	−71	−79	−86	−93	−101	−109	−116
35	20	12	4	−4	−12	−20	−27	−35	−43	−52	−58	−67	−74	−82	−89	−97	−105	−113	−120
40	19	11	3	−5	−13	−21	−29	−37	−45	−53	−60	−69	−76	−84	−92	−100	−107	−115	−123
45	18	10	2	−6	−14	−22	−30	−38	−46	−54	−62	−70	−78	−85	−93	−102	−109	−117	−125

Dry bulb temperature (°F)

Figure 1. Wind-chill equivalent temperature.

For example, a temperature of 95°F, with a relative humidity of 55% indicates a Temperature-Humidity Index of 86.[4] This condition will impede outdoor work (fig. 2). On the other hand, an air temperature of 5°F and a wind speed of 5 mi/h yield a

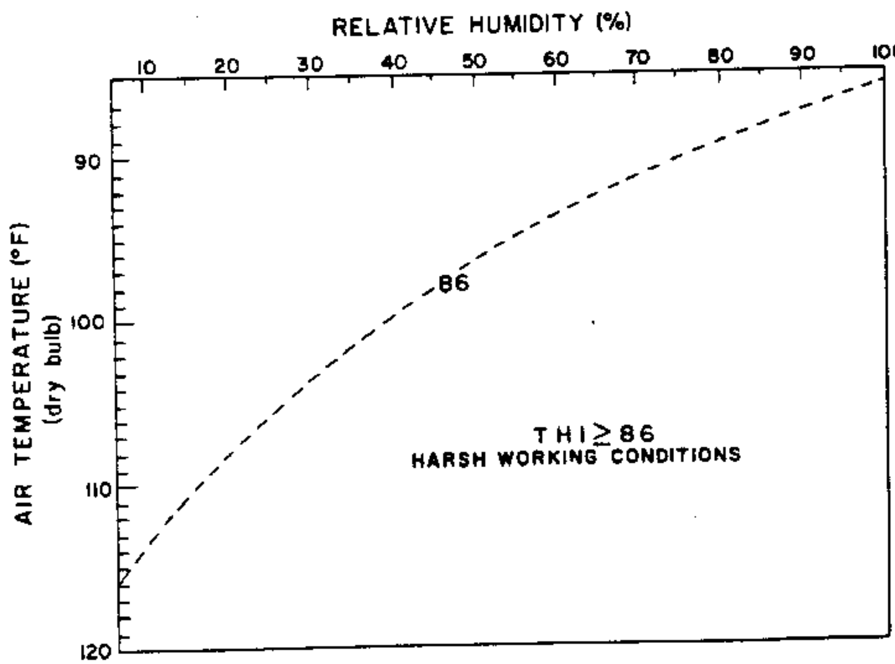

Figure 2. Temperature-Humidity Index indicating harsh working conditions.

[4]The official Government Heat-Humidity Index advises the release of many federal employees when the Temperature-Humidity Index reaches approximately 86, e.g., 95°F and 55% RH are one combination.

wind-chill equivalent temperature of 0°F. Again, outdoor work will be impeded.

Precipitation, temperature, and wind affect observers much as they do builders, since both climb the towers. However, there is a major difference. The observer relies largely on visual observation. Thus, visibility, or atmospheric phenomena affecting visibility or light penetration of distance-measuring equipment, are of great importance. Webster defines visibility as "the possibility of being seen under the conditions of distance, light, and atmosphere prevailing at a particular time." The atmospheric phenomena which can readily lower visibility include any one or any combination of the following: fog, smog, precipitation, blowing snow or sand, clouds in hilly or mountainous terrain, and haze, a general term for reduced visibilities resulting from any combination of dust, smoke, mist, fog, vaporous fumes, or particulate matter. Visibilities necessary to complete jobs vary with location and type of work. Urban work may require lines of sight of only 2 or 3 miles, while arcs in the southwest deserts may average 20 miles between stations. Overall, however, visibilities of 7 miles or less will usually result in delays or losses in scheduled observations.

Since observing is carried out primarily on exposed towers, wind is of great importance. Winds of 20 mi/h or more not only create generally unsafe conditions, but also physically shake the tower. Occupation of a tower during these conditions may not only be unsafe, but observations taken are often unacceptable.

Other factors which affect observing include temperature and precipitation. Since observing is usually accomplished after dark, cold is the greatest interrupter of work. A wind-chill equivalent temperature of 0°F or lower is normally sufficient to impede observation from towers.

Precipitation interrupts observing. Not only does the danger of slipping on wet surfaces increase, but visibility decreases as precipitation rates increase. Precipitation also frequently creates fog and low clouds which restrict visibility. An hourly precipitation rate of 0.02 inch is sufficient to restrict operations. (See table 1, page 7, for detailed summary of limits at which weather elements interrupt field operations.)

Vertical Control Parties

Vertical control procedures are not nearly so sensitive to restricted visibilities as are horizontal control procedures, because lines of sight normally will not exceed 300 feet. However, the operation is by no means immune to inconvenience

Table 1.--Limits at which weather elements interrupt field operations.

Weather element	General conditions under which work cannot proceed	Kind of operation affected
Precipitation	0.02 or more inch/hour	Horizontal control (HC) Vertical control (VC)
	Trace* or more	Astronomic (A)
Temperature	Wind-chill equivalent temperature ≤ 0°F	HC, VC, A
	Temperature-Humidity Index ≥ 86	HC, VC
Visibility	< 7 miles	HC
	Near 0 (dense fog)	VC
Wind	Average speed 20 mi/h or higher**	HC
	Average speed 15 mi/h or higher**	VC
Sky cover	50% or more of sky covered with clouds	A

*Trace: less than 0.01 inch.

**Gusts can occur with wind speeds at or above 15 mi/h, particularly over rough terrain. Difference in wind speed between peaks and lulls is at least 10 mi/h. Gust duration is usually 20 seconds or less.

created by other adverse atmospheric conditions. The major meteorological elements affecting vertical control parties, both bench mark setters and observers, are precipitation, wind, and temperature. Precipitation hinders ground work much the same as in horizontal control operations. Amounts of 0.02 inch per hour can stop work. Again, duration and frequency of precipitation are more important than total amounts. Wind, even at ground level, is critical. Winds of 15 mi/h or more can shake levels and rods, resulting in unacceptable readings.

Temperatures can impede vertical control work. Refraction by high temperature will necessitate shortening of foresights and backsights, resulting in lost time. When the Temperature-Humidity Index reaches 86, work is difficult, and wind-chill equivalent temperatures of 0°F or lower can also terminate operations. Ice or snow in areas of cold weather can result in lost work because of loss of mobility. (See table 1 for detailed summary.)

Astronomic Parties

Both precipitation and cloud cover are of major concern to astronomic parties as star observations require fairly clear skies. Precipitation of any type will immediately halt astronomic observations. Since a trace or more of precipitation usually indicates cloudy or mostly cloudy conditions, precipitation falling at this rate is usually enough to interrupt scheduled work. Work also can be halted with as little as 50% cloud cover. Other elements, such as wind and temperature, occasionally create problems. Wind can, however, usually be blocked by trucks or canvas shields, and temperatures are secondary to cloud cover. (See table 1.)

II. TYPES AND SOURCES OF CLIMATOLOGICAL DATA

General information on large-scale climatic conditions is useful and necessary in the planning of NGS field operations. Large-scale patterns of climatic variables must be known before individual elements can be analyzed and evaluated. Evaluation of specific individual elements is essential, since certain variations of just a few elements cause a large percentage of interruptions to NGS field operations.

Climatological data are available in raw or processed forms. Raw data listings probably are the least useful for NGS purposes. The processed, analyzed forms that should be most useful for NGS plans and operations are available in the form of tabulated means and extremes, nomograms, graphs, charts, and maps. All are easily used and all are readily available. Climatic information is available at three basic geographic scales: regional, state, and local. The kinds and sources of climatic information available at each of these scales are described next. Publications containing this information should be obtained by every NGS office engaged in planning of operations to facilitate the use of climatic information in geodetic surveying. (See appendix I for details.)

A. Regional Level

The *Climatic Atlas of the United States*, a NOAA publication, is a valuable reference to regional climatic characteristics. It depicts the climate of the United States in terms of distribution and variation of climatic elements. Data are illustrated by climatic maps on 16- by 24-in. pages. Isolines are used, so that overall patterns of distribution are quickly evident (fig. 3). Pertinent information illustrated includes data on temperatures, snowfall, rainfall, days with rainfall, wind velocity, sky cover, and other elements. The 40 pages of this atlas contain 271 climatic maps and 15 tables.

B. State Level

More detailed climatic information is available at the state level than at the regional level. The publication entitled *Climates of the States* combines into two convenient volumes the summaries for the 50 states, Puerto Rico, and the U. S. Virgin Islands. Included in each summary is a narrative description of general climatic conditions, detailed tables of freeze data, maps illustrating precipitation and amounts, and locations of stations. Other data, such as snowfall, sunshine, and occurrence of tropical storms are included when pertinent. The two volumes contain a total of 310 maps and 395 tables. The original NOAA publications from which these volumes were compiled are available in the Environmental Data Service (EDS) series *Climates of the States: Climate of (name of state)*, for each state, Puerto Rico, and the Virgin Islands.

C. Local Level

Local climatological information is available for many airports, towns, cities, and a few parks. The data found at this level are more detailed and extensive than that of the other levels. There is a large amount of information at the local level which can be of value in the planning of NGS field operations.

Valuable information on precipitation, visibilities, sky cover, and wind speed is available for over 150 cities located in the United States in *Summary of Hourly Observations (1951-1960)*. This is a monthly summary of observations in tabular form at 24-hour National Weather Service stations. Figure 4 shows types of data that are of special interest. These summaries include a narrative description of the location and topography of the station. Where pertinent, local smoke sources are described, and a smoke source map is furnished. This publication contains data essential to any climatic planning that may be undertaken in NGS.

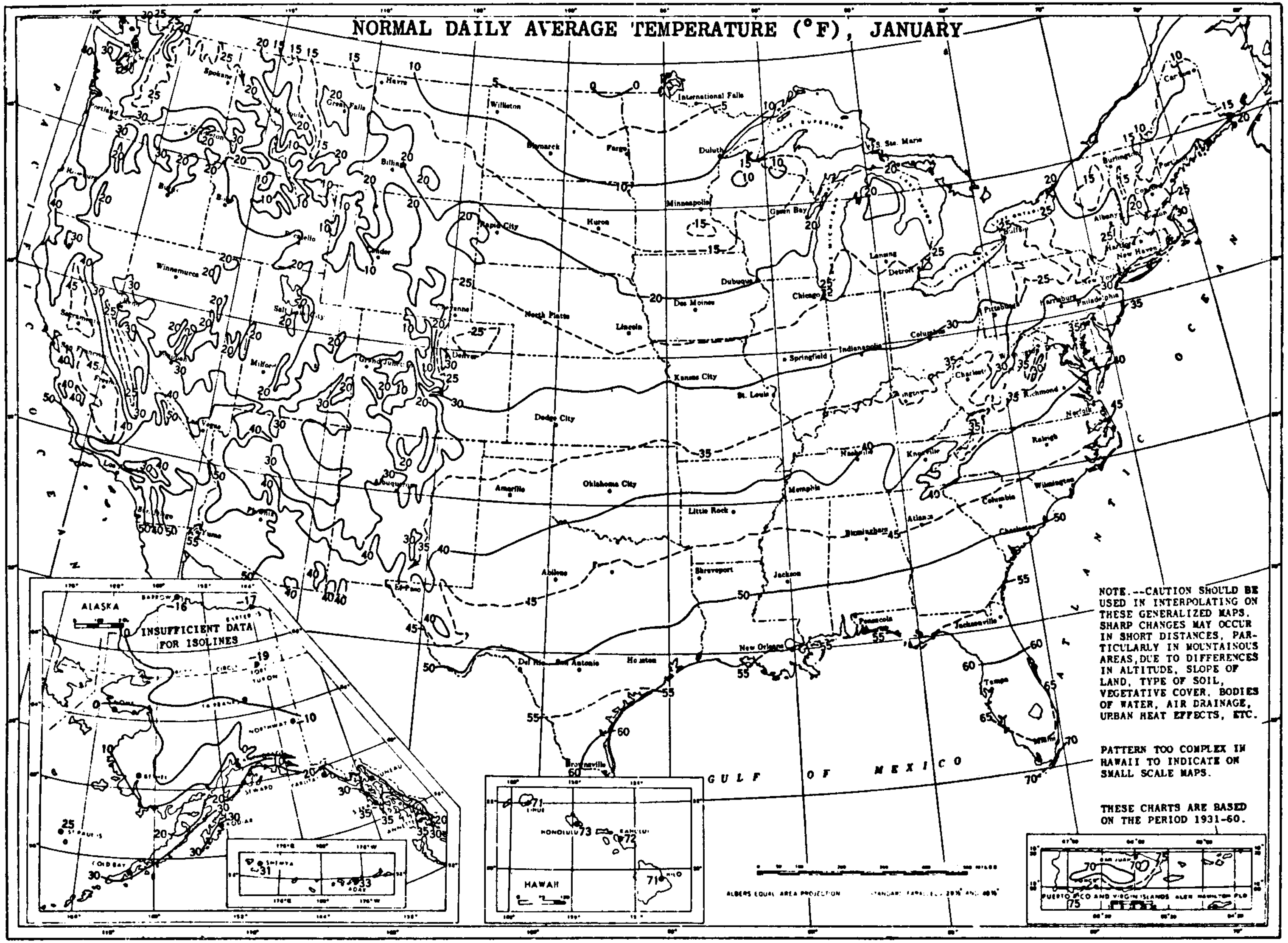

Figure 3.--A typical isoline map (*Climatic Atlas of the United States*).

WASHINGTON, D.C.
National Airport

JANUARY
7440 Obs.

A TEMPERATURE AND WIND SPEED–RELATIVE HUMIDITY OCCURRENCES:

WIND	0-4 M.P.H.						5-14 M.P.H.						15-24 M.P.H.						25 M.P.H. AND OVER						TOTAL OBS.
REL. HUMID. / TEMP. (°F)	UNDER 30%	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30%	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30%	30-49%	50-69%	70-79%	80-89%	90-100%	UNDER 30%	30-49%	50-69%	70-79%	80-89%	90-100%	
74/ 70								1						1	3										5
69/ 65								2	10		1		1	3	6	2	2								27
64/ 60		1	12	4	2		4	5	9	7	5	7	1	5	4	6	19	6		1		6	6	1	111
59/ 55		4	6		4	10	5	22	22	8	8	32	1	15	10	6	8	5		7					173
54/ 50		6	10	3	2	19	7	35	36	25	26	53	13	22	18	10	20	12	4	1	2	2			326
49/ 45		7	40	8	29	42	10	58	96	36	54	54	6	49	38	13	30	12		13	12	1			608
44/ 40		17	47	31	12	74	10	187	230	102	84	135	9	114	87	24	51	53	3	15	7	1	1	1	1295
39/ 35	3	22	81	55	54	94	4	193	435	131	127	185	6	141	151	44	8	47		22	9		1	2	1815
34/ 30		10	75	70	73	83		158	355	125	127	155	1	115	155	17	12	32		8	26	2	1		1600
29/ 25	3	15	42	21	17	11	3	115	178	72	26	18	4	77	96	10	4	11		9	20		1	1	754
24/ 20		9	17	16	13	8		59	141	33	32			44	76	4	8	7		4	5				476
19/ 15		4	14	14	2			15	62	20	19			14	16					1					181
14/ 10		2	10	5				4	26	5	5			3	3	2									65
09/ 05									2	1	1														4
TOTAL	6	97	354	227	208	341	43	854	1602	565	515	639	42	603	663	138	162	185	7	81	81	12	10	5	7440

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 OVER	TOTAL	AV. SPEED
N	1	1	1	1	+	+	+			5	11.1
NNE	+	1	1	1	+					4	11.0
NE	+	1	2	1	+	+				4	9.8
ENE	+	1	1	1	+					3	9.4
E	+	1	+	+	+					1	6.6
ESE	+	1	1	+						2	7.4
SE	1	1	+	+	+					2	6.8
SSE	+	1	2	+	+					3	7.9
S	1	4	4	2	+	+				11	8.8
SSW	1	3	4	3	1	+				11	10.7
SW	1	2	1	1	+	+				4	7.8
WSW	+	1	1	+	+	+				3	7.9
W	+	1	1	1	+	+				3	10.3
WNW	+	1	3	5	2	1	+			12	14.7
NW	+	2	5	6	3	1	+			16	14.0
NNW	+	2	3	4	1	+	+			11	13.5
CALM	4									4	
TOTAL	11	22	30	25	9	2	+			100	10.8

C OCCURRENCES OF PRECIPITATION AMOUNTS:

INTENSITIES	FREQUENCY OF OCCURRENCE FOR EACH HOUR OF THE DAY — A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	NOON	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	MID.	NO. OF DAYS WITH
TRACE	33	30	35	31	35	41	41	39	34	29	25	24	24	33	30	23	19	18	27	26	22	20	25	26	44
.01 IN	6	8	5	4	5	9	9	9	5	7	9	11	7	4	6	9	14	10	6	5	6	6	4	13	15
.02 TO .09 IN	17	14	17	20	17	13	16	11	19	17	17	18	17	14	18	16	10	12	12	14	16	14	21	21	29
.10 TO .24 IN	2	2	1	3	4		1	1	1	4	4	1	1	3	2			3	1	2	1	5	2		30
.25 TO .49 IN	1	1	1			1	1	3						1										1	23
.50 TO .99 IN																									13
1.00 TO 1.99 IN																									1
2.00 IN AND OVER																									
TOTAL	59	55	59	58	61	64	68	63	59	57	55	54	49	55	56	48	43	43	46	47	45	45	52	61	155

D PERCENTAGE FREQUENCIES OF CEILING–VISIBILITY:

VISIBILITY (MILES)	CEILING (FEET) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	OVER 9500	TOT.
0 TO 1/8	+	+						+		+
3/16 TO 3/8	+	+	+	+		+				1
1/2 TO 3/4	+	+	+	+	+	+		+	+	1
1 TO 2 1/2		+	1	3	1	+	+	1	1	7
3 TO 6			+	2	2	1	2	3	8	19
7 TO 15			+	+	2	2	5	9	55	73
20 TO 30										
35 OR MORE										
TOTAL	+	1	2	5	5	4	7	12	64	100

E PERCENTAGE FREQUENCIES OF SKY COVER, WIND, AND RELATIVE HUMIDITY:

HOUR OF DAY	CLOUDS SCALE 0-10: 0-3	4-7	8-10	WIND SPEED (M.P.H.): 0-3	4-12	13-24	25-& OVER	RELATIVE HUMIDITY (%): 0-29	30-49	50-69	70-79	80-89	90-100
00	45	7	48	17	54	27	2	1	11	44	13	15	17
01	41	8	51	15	55	29	2		12	42	14	14	18
02	40	6	54	15	57	26	2		10	39	16	15	19
03	38	7	55	17	54	27	2		8	38	17	16	21
04	41	7	52	15	54	28	2		6	39	16	18	21
05	41	8	52	17	55	25	2		8	35	18	16	23
06	38	9	53	17	57	25	2		8	35	18	19	20
07	28	14	58	18	53	27	1	+	9	32	19	19	20
08	30	10	60	13	58	28	1		9	37	16	16	21
09	30	10	60	10	54	33	3		15	40	15	14	16
10	29	13	58	8	47	42	4		22	39	14	11	14
11	28	11	61	6	46	42	5	1	36	29	13	11	10
12	28	13	59	4	47	46	3	2	40	30	10	10	8
13	29	12	59	5	45	45	5	3	43	29	7	8	9
14	30	13	56	7	43	45	5	5	44	28	6	8	8
15	32	13	55	5	47	45	3	5	44	28	6	7	9
16	33	10	58	7	47	42	4	5	41	30	6	7	10
17	37	6	56	9	50	39	2	3	37	35	9	6	11
18	40	9	51	9	55	34	2	1	33	38	10	8	10
19	43	7	50	10	56	33	1	1	26	41	12	10	10
20	44	6	50	9	55	34	2	1	21	44	12	10	12
21	45	6	49	11	57	30	2	+	19	44	13	12	13
22	45	8	47	10	57	31	2	+	15	46	14	9	16
23	44	6	50	16	52	30	2	+	13	42	18	11	16
AVG	37	9	54	11	52	34	2	1	22	37	13	12	15

Figure 4.--Meteorological data contained in *Summary of Hourly Observations (1951-1960)*.

Another convenient descriptive source for local climatological data is a series of publications called *Climatological Substation Summaries*. These are usually printed on one or two sheets (figs. 5 and 6). They present a "means and extremes" table and sequential tables of monthly and annual average temperatures and total precipitation. Included is a narrative summary of the local climate. The period of record covered is usually 15 to 30 years. These publications are available for approximately 1,200 locations across the country, mainly cities and towns, and for some parks and recreational areas (e.g., Upper Cascades of Oregon). The large number and wide distribution of these climatological summaries warrant their use in determining the general climatic conditions prevailing in specific geographical areas.

III. TYPES, SOURCES, AND APPLICATIONS OF AVAILABLE CURRENT WEATHER INFORMATION AND FORECASTS

Current weather information depicts atmospheric conditions at the time of observation. The data are used to forecast weather conditions which will occur at given times. Forecasts for periods up to 120 hours in the future are produced twice daily by the Forecast Division of the National Weather Service. Emphasis is placed on the 24- to 72-hour forecasts. Another NWS group, Long-Range Prediction, prepares outlooks for periods of one month. These outlooks attempt to depict very general precipitation and temperature patterns with respect to normal conditions. Terms such as heavy, light, normal, and above normal are used (fig. 7). This monthly forecast is not sufficiently reliable for use by NGS field or office operations.

Shorter range forecasts (5 days or less) may be of value, especially for parties in the field. Office planning usually requires that work schedules be developed months ahead of time. This limits application of current short-range weather forecasts to field operations.

More specific information on current and projected weather conditions than that furnished for public use is available to NOAA-related activities and personnel through an extensive national forecast network. The network consists of 260 stations, many of which are located in or around city airports (fig. 8). Specific questions or problems concerning weather conditions can be discussed with the duty forecaster by telephone or in person. This type of service can be of considerable benefit to field personnel.

Another excellent source of information for current and future local weather conditions is the NWS Continuous Weather Broadcast VHF-FM radio stations. These stations broadcast 24 hours a day, providing the listener with continuous weather information.

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
IN COOPERATION WITH GARRETT COUNTY DEVELOPMENT CORPORATION
CLIMATOGRAPHY OF THE UNITED STATES NO. 20 — 18

LATITUDE 39° 37'N.
LONGITUDE 79° 15'W.
ELEV. (GROUND) 2700 feet

CLIMATOLOGICAL SUMMARY

STATION BITTINGER (2 miles NW)

MEANS AND EXTREMES FOR PERIOD June 1953 - December 1970

Month	Temperature (°F) Means: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Mean degree days **	Precipitation Totals (Inches): Mean	Greatest daily	Year	Snow, Sleet ***: Mean	Maximum monthly	Year	Greatest daily	Year	Mean number of days: Precip. .10 inch or more	Temperatures Max.: 90° and above	32° and below	Min.: 32° and below	0° and below	Month
(a)	17	17	17	17		17		17	17	17		18	18		18		17	17	17	17	17	
Jan	32.7	15.2	24.0	64	1967	-23	1963	1262	3.16	1.55	1957	26.3	42.0	1958	11.5	1966	9		16	29	4	Jan
Feb	35.5	17.3	26.4	69	1954	-16	1958	1084	3.66	1.80	1959	24.3	52.7	1964	15.0	1961	10		12	26	3	Feb
Mar	43.6	24.1	33.9	76	1966	-4	1960	957	4.62	2.28	1954	22.3	43.1	1960	10.0	1962	12		7	25	*	Mar
Apr	58.0	36.0	47.0	84	1957	10	1965	533	4.37	1.43	1958	6.2	28.3	1962	6.8	1961	11		*	12		Apr
May	67.2	44.4	55.8	89	1959	19	1966	291	3.96	2.27	1960	0.2	3.0	1954	3.0	1954	10			3		May
Jun	73.9	52.5	63.2	88	1969+	29	1966	105	3.98	2.33	1955						8	*		*		Jun
Jul	77.0	56.6	66.8	92	1954	38	1963	35	4.30	2.52	1970						9	*				Jul
Aug	75.4	55.6	65.5	90	1955	35	1965	52	3.95	2.94	1954						7	*				Aug
Sep	69.7	49.4	59.6	84	1964+	26	1962	190	3.15	2.00	1965+						7			1		Sep
Oct	59.4	39.4	49.4	81	1959	13	1963	481	3.02	5.36	1954	0.6	6.1	1962	3.5	1962	6		*	7		Oct
Nov	47.1	29.7	38.4	74	1958	-4	1958	789	3.19	1.70	1963	9.5	23.4	1967	11.5	1968	9		4	19	*	Nov
Dec	35.9	19.5	27.7	69	1966	-10	1960	1149	3.61	2.00	1957	23.8	55.2	1969	11.5	1962	11		13	27	1	Dec
Year	56.3	36.6	46.5	92	1954	-23	1963	6928	44.97	5.36	1954	113.7	55.2	1969	15.0	1961	109	1	52	149	8	Year

(a) Average length of record, years.

T Trace, an amount too small to measure.

** Base 65°F

+ Also on earlier dates, months, or years.

* Less than one half.

***Snowfall - 18 seasons, 1953/54 - 1970/71

CLIMATE OF BITTINGER, MARYLAND

Bittinger, located in northcentral Garrett County, lies within the Appalachian Plateau physiographic province. The weather station is located in a relatively flat, open area, oriented SW-NE, with slightly higher ground, less than 100 feet, to the north, south and west and a gentle slope downward toward the east. A forest of pine and hardwood trees surround the area. This station records more snowfall and more continuous snow cover than any other of Maryland's currently operating weather stations. It also has lower monthly and annual mean temperatures than does Oakland, long recognized for its lowest temperatures in Maryland. While Bittinger's mean daily maximum temperature is considerably lower than that of Oakland's, its mean daily minimum is not quite as low for all months.

Bittinger has a humid, continental climate by reason of its 45-inch average annual precipitation and its location in the middle latitudes where the general atmospheric flow is from west to east across the North American continent. During the colder half of the year, a frequent succession of high and low pressure systems move along in this flow bringing alternate surges of cold, dry air from the north and warm, humid air from the south. This accounts for much of the variety in the weather from day to day. During the summer this pattern tends to break down as warm, moist air spreads northward from the south and the southeast and remains over the area much of the time.

The warmest period of the year is the last half of July when the maximum temperature averages about 80°F. Temperatures of 90°F. or higher occur on an average of one day per year. During this 17-year period, only 1953 had as many as 7 days while 13 of the years had none. The coldest period, on the other hand, is the last of January and the beginning of February when early morning temperature averages about 12°F. The average annual number of days when the daily minimum temperature is 32°F. or lower is 149 and has ranged from 136 in 1965 to 159 in 1969. The annual number of days when the minimum temperature is 0°F. or lower is 8 and has ranged from one in 1956 to 18 in 1963.

Bittinger's annual precipitation is 45 inches and during this 17-year period has ranged from 38.59 inches in 1969 to 58.07 inches in 1956. The ascent of moisture laden air masses over the high elevations of Garrett County is the "trigger action" that brings about the generally abundant precipitation of the area. Long-time averages indicate that late spring or summer will likely have the wettest month while autumn months will have the driest.

The average seasonal snowfall is 114 inches and has ranged during 18 seasons from 65 inches in the 1958/59 season to 161 inches in the 1969/70 season. The greatest depth on the ground is 35 inches on February 8, 1961. The following are the average dates of the first and last snowfalls of the season: 1 inch - November 11, April 9; 2½ inch - November 27, April 4. The monthly and annual number of days with at least one inch of snow on the ground is as follows: January, 25; February, 22; March, 17; April, 3; November, 5; December, 19; Annual, 91.

Thunderstorms, based on a 15-year period at Oakland, occur on an average of 35 days; while they may occur in any month, 75% of them occur during the months, May through August. They may be accompanied by heavy rain, damaging winds, hail and/or intense lightning.

About once every three or four years, tropical storms or hurricanes affect the area, generally during the period, August through October. They usually produce heavy rainfall but seldom have winds exceeding 50 m.p.h. The most notable in the last 20 years was Hurricane Hazel of October 15, 1954 during which the greatest one-day rainfall of 5.36 inches was recorded. Tornadoes are rare; two per year, on the average, are reported in the entire state. There are no actual wind observations for Bittinger, however, wind records in the area indicate west to northwest prevailing winds except during the summer when they become more southerly. Average annual wind speed is about 9 m.p.h. but may reach 50 to 60 m.p.h. or even higher during thunderstorms or intense winter storms.

The average date of the last 32-degree temperature in the spring is May 16th and the first in the fall is October 2nd. The growing season, defined as the number of days between the last 32-degree temperature in the spring and the first in the fall, averages 138 days. The following table gives the probability (in percent) of last spring and first fall occurrences of temperatures 32°, 24° and 16°F.

Temperature	10%	33%	50%	67%	90%
AFTER DATE IN SPRING					
32° or below	May 31	May 21	May 16	May 11	May 1
24° or below	May 8	Apr 26	Apr 20	Apr 14	Apr 2
16° or below	Apr 6	Mar 28	Mar 24	Mar 20	Mar 11
BEFORE DATE IN FALL					
32° or below	Sep 19	Sep 27	Oct 2	Oct 7	Oct 15
24° or below	Oct 15	Oct 24	Oct 29	Nov 3	Nov 12
16° or below	Oct 31	Nov 10	Nov 15	Nov 20	Nov 30

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Room 101, Jull Hall
College Park, Maryland 20742
University of Maryland
January 1972

Figure 5.--Local climatological data (*Climatological Substation Summaries*).

Average Temperature (°F)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
1953						66.1	69.2	67.0	60.3	53.4	40.4	32.8	--
1954	27.9	33.2	34.1	52.5	52.7	64.7	66.9	65.0	61.7	51.1	36.0	26.1	47.7
1955	23.1	28.8	37.6	51.2	58.8	59.5	71.5	68.7	60.6	50.6	35.6	24.5	47.5
1956	23.4	31.2	33.2	43.8	55.7	63.2	66.0	65.0	56.8	51.7	37.4	36.8	47.0
1957	22.8	33.1	34.8	49.4	58.1	65.8	66.8	65.0	60.9	45.1	39.2	31.9	47.7
1958	22.1	18.6	30.0	46.7	55.4	59.8	68.5	64.7	59.7	48.0	41.8	21.6	44.7
1959	24.1	29.1	34.2	49.5	60.1	63.7	68.0	69.8	63.1	50.2	36.1	32.3	48.4
1960	28.0	25.5	22.7	50.6	53.1	62.9	64.4	67.8	61.1	49.4	39.8	21.8	45.6
1961	20.2	30.4	36.8	39.5	51.2	61.8	66.9	66.3	64.0	51.6	39.8	28.6	46.4
1962	24.8	28.4	33.1	45.0	60.3	63.8	64.0	65.3	55.1	49.9	36.3	23.7	45.8
1963	22.6	19.2	38.6	46.9	53.9	62.8	64.6	62.0	56.2	54.9	40.5	19.1	45.1
1964	28.4	24.3	35.6	48.8	57.7	63.1	66.2	62.8	59.7	46.1	42.9	32.0	47.1
1965	24.5	28.0	31.0	45.5	61.1	61.9	65.5	65.0	62.0	46.4	39.1	33.1	46.9
1966	20.4	26.5	37.1	41.8	53.8	63.8	68.2	65.3	55.8	45.9	40.7	27.6	45.6
1967	30.4E	23.7	36.7	47.5	49.6	64.7	64.7	62.7	54.7	47.2	32.5	31.3	45.5E
1968	21.5E	19.1	39.0	47.5	51.7	63.1	66.5	66.8	59.0	48.9	39.1	28.1	45.9E
1969	23.4E	25.4	30.2	48.6	57.2	64.3	67.6	64.6	57.6	47.7	34.9	22.7	45.4E
1970	19.3	25.0	30.7	47.2	59.2	63.4	66.6	65.7	63.2	51.1	39.4	29.4	46.7

RAINFALL FREQUENCY FOR DURATIONS FROM 5 MINUTES TO 24 HOURS AND FOR RETURN PERIODS FROM 2 TO 100 YEARS FOR BITTINGER AREA (VALUES GIVEN IN INCHES)

Return Period	5-Min	30-Min	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour
2-year	0.4	1.1	1.3	1.8	2.1	2.4	2.8
10-year	0.6	1.5	2.0	2.6	3.0	3.7	4.4
25-year	0.7	1.8	2.3	3.0	3.7	4.4	4.8
50-year	0.8	2.0	2.5	3.4	4.0	4.8	5.5
100-year	0.9	2.3	2.8	3.7	4.5	5.4	6.0

For Example: The 2-year 1-hour rainfall given in the table as 1.3 inches means that this value will be equalled or exceeded, on an average, once every two years.

From: U.S. Weather Bureau, Technical Paper No. 40, Rainfall Frequency Atlas of the United States, May 1961.

STATION HISTORY

Bittinger cooperative weather station, located 2 miles northwest of the local post office, has been operated by Elbert E. Buchel. Records from this excellent station date back to May 11, 1953.

MAXIMUM DEPTH OF SNOW ON GROUND (INCHES)

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Seasonal Maximum
1953-1954	0	3	9	13	7	3	0	0	13
1954-1955	0	5	14	16	13	3	T	0	16
1955-1956	0	6	5	10	4	8	3	0	10
1956-1957	0	4	6	10	7	5	T	0	10
1957-1958	2	2	11	13	21	24	9	0	24
1958-1959	0	4	7	5	2	8	5	0	8
1959-1960	0	4	11	7	19	33	3	0	33
1960-1961	T	3	18	20	35	7	11	0	35
1961-1962	T	2	7	6	8	19	7	0	19
1962-1963	4	3	20	13	14	13	T	0	20
1963-1964	0	10	20	28	33	27	T	0	33
1964-1965	0	4	4	12	7	11	3	0	12
1965-1966	2	4	5	20	26	8	10	T	26
1966-1967	0	10	8	6	14	13	T	0	14
1967-1968	0	6	13	22	12	16	0	0	22
1968-1969	T	12	11	15	13	16	1	0	16
1969-1970	0	5	23	24	17	11	3	0	25
1970-1971	T	1	13	21	20	15	4	T	21

Total Precipitation (Inches)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
1953						0.89	2.55	2.69	1.50	0.85	1.23	2.59	--
1954	2.95	1.86	4.76	2.48	3.16	6.07	2.11	9.94	3.58	9.51	2.54	4.14	53.10
1955	2.19	3.41	7.93	3.43	2.60	4.73	4.01	5.97	2.50	1.75	2.44	0.99	41.95
1956	3.21	5.95	4.76	4.12	7.29	6.76	4.07	8.76	3.76	2.18	2.64	4.57	58.07
1957	4.63	4.73	3.12	5.11	2.78	3.78	3.48	1.78	2.90	5.67	2.02	5.44	45.44
1958	4.06	3.21	2.88	4.75	5.79	4.13	6.21	3.91	3.83	2.19	3.18	1.51	45.65
1959	3.27	4.28	3.16	4.93	2.67	2.12	5.33	3.14	2.28	4.97	4.06	3.64	43.85
1960	4.25	4.39	2.95	3.10	6.55	1.95	4.94	1.89	4.95	2.16	1.88	2.74	41.80
1961	2.56	5.24	6.03	6.47	4.27	6.12	5.39	3.32	1.23	2.61	3.17	4.18	50.59
1962	3.67	4.57	4.90	4.35	3.86	3.54	4.08	1.28	4.91	4.67	2.84	3.54	46.21
1963	1.41	2.57	7.31	3.23	2.01	4.21	4.06	4.13	1.75	0.45	6.07E	2.79	39.99E
1964	3.20	4.55	4.11	7.34	2.10	7.12	3.63	2.42	3.43	1.11	3.76	4.14	46.91
1965	5.19	2.99	5.14	4.82	1.55	2.04	3.06	3.91	4.31	3.44	2.20	1.30	39.95
1966	4.01	4.69	2.37	5.78	2.71	1.39	2.95	3.37	4.77	2.71	4.03	1.90	40.68
1967	1.63	3.52	8.01	4.50	7.34	2.30	4.72	3.58	2.10	2.93	3.64	3.90	48.17
1968	2.42	1.28	4.05	1.77	7.13	4.95	2.54	3.98	2.33	2.62	5.48	4.43	42.98
1969	2.32	2.41	2.43	2.77	1.88	2.64	7.14	2.95	2.50	1.54	3.36	6.65	38.59
1970	2.74	2.60	4.71	5.39	3.59	6.89	7.17	4.03	4.07	3.00	2.85	6.57	53.61

MONTHLY AND SEASONAL SNOWFALL (INCHES)

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total (or Seasonal)
1953-1954	0	5.6	13.4	29.5	11.4	11.7	0	3.0	74.6
1954-1955	0	13.7	29.5	24.0	15.0	8.1	T	0	90.3
1955-1956	0	16.3	9.8	21.2	4.1	21.9	6.6	T	79.9
1956-1957	0	7.6	11.1	21.2	15.9	15.0	0.3	0	71.1
1957-1958	2.2	3.1	21.1	42.0	33.7	31.1	1.1	0	134.3
1958-1959	T	4.3	13.9	23.0	6.6	12.0	5.0	0	64.8
1959-1960	T	8.5	23.4	14.2	40.6E	43.1	10.8	1.0	141.6E
1960-1961	0.5	7.5	40.0	27.8	36.1	13.8	23.7	T	149.4
1961-1962	T	6.7	17.9	15.6	17.2	29.6	28.3	0	115.3
1962-1963	6.1	5.4	42.2	12.9	29.8	15.8	T	0	112.2
1963-1964	T	13.3E	28.1	25.1	52.7	17.8	1.0	0	138.0
1964-1965	0	3.8	8.1	28.4	16.1	27.6	2.8	0	86.8
1965-1966	1.8	6.0	9.4	32.3	36.1	13.6	14.2	T	113.4
1966-1967	T	15.1	17.0	10.6	33.0	20.5	T	T	96.2
1967-1968	T	23.4	18.6	23.8	18.0	18.4	T	0	102.2
1968-1969	0.5	17.7	37.6E	13.2E	27.1	29.1	1.2	T	126.4E
1969-1970	0	10.1	55.2	33.1	24.3	29.7	8.4	0	160.8
1970-1971	T	3.3	31.3	34.7	19.7	41.8	8.3	T	139.1

NUMBER OF DAYS WITH SNOW ON GROUND ONE INCH OR MORE

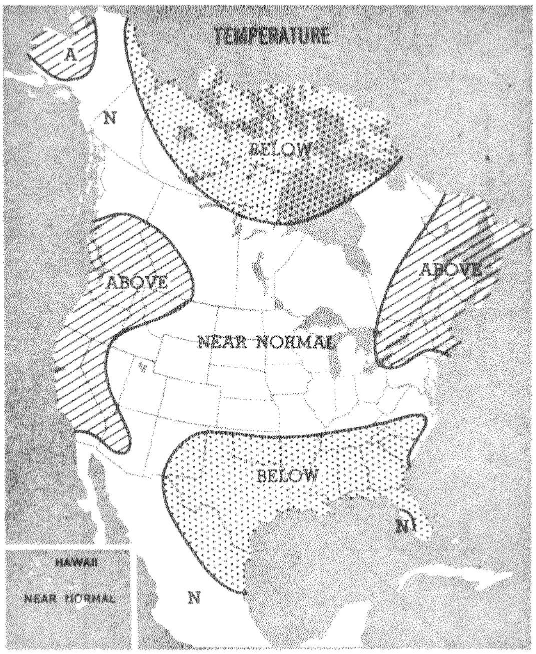
Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total (or Seasonal)
1953-1954	0	5	9	20	11	12	1	0	58
1954-1955	0	10	28	20	21	6	0	0	85
1955-1956	0	8	17	24	9	11	4	0	73
1956-1957	0	10	10	30	15	14	0	0	79
1957-1958	1	2	14	31	28	31	3	0	110
1958-1959	0	4	28	22	9	8	2	0	73
1959-1960	0	5	16	12	20	29	4	0	106
1960-1961	0	4	24	31	24	8	11	0	102
1961-1962	0	6	16	24	21	18	7	0	92
1962-1963	2	4	25	28	28	19	0	0	106
1963-1964	0	2	31	31	29	12	0	0	105
1964-1965	0	1	12	25	15	23	1	0	77
1965-1966	1	5	12	23	28	12	6	0	81
1966-1967	0	3	9	16	21	17	0	0	66
1967-1968	0	12	14	31	29	17	0	0	103
1968-1969	0	7	25	23	26	22	1	0	104
1969-1970	0	6	31	31	28	26	4	0	126
1970-1971	0	2	17	31	26	22	2	0	100

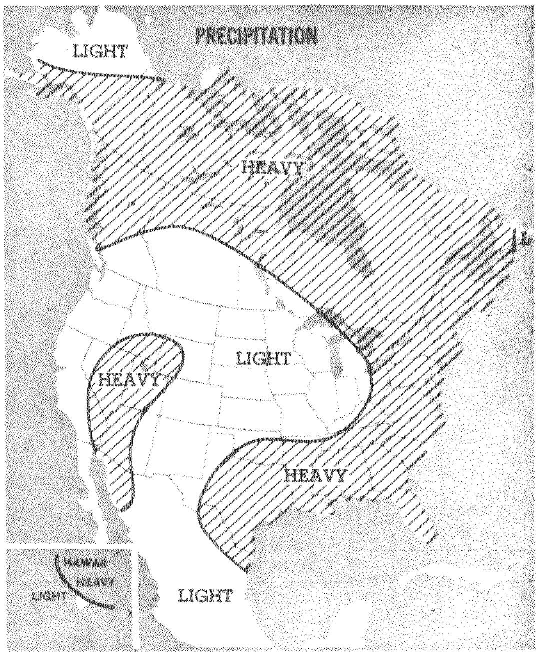
Figure 6.--Page from same publication shown in figure 5.

average monthly weather outlook

U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration • National Weather Service

FOR MID-AUGUST TO MID-SEPTEMBER 1975





The numerical definitions of the labels on these charts are given on page 3 for the conterminous United States, Alaska, and Hawaii.

CAUTIONARY NOTE: The 30-day Outlook given here is not a special forecast in the usual meteorological sense, but is an estimate of the average rainfall and temperature for the next 30 days. It is based upon an analysis of meteorological observations from a major part of the Northern Hemisphere. While their number runs into thousands, there are still many areas which are relatively uncovered and whose characteristics the meteorologist must estimate before attempting to predict. But even if the world were covered with a dense network of observation posts, meteorologists today would be unable to foretell in detail the weather for the next 30 days. The reason for this lies in the great complexity of the circulation of the atmosphere: weather events in each area affect those in other, even remote, areas in a way yet imperfectly understood. During the past decade extensive research by meteorological organizations around the world has thrown some light on these complex interactions. The application of this research to problems of 30-day forecasting and the extension of knowledge brought about by concentrated effort and experience over the past decade have enabled the National Weather Service to make general 30-day predictions of temperature and precipitation with some modest success.

Because of the uncertainties involved in present methods, however, the user of the Outlook should feel less secure about the prediction when the area that concerns him lies near the borders of the classes of temperature and precipitation than when the area is well within the boundaries. Although the general pattern of temperature over the United States may frequently be predicted correctly, a displacement of the pattern can produce major errors in certain localities. Too much weight should not, therefore, be given to one forecast and especially to one forecast for a specific point. Thus the Outlook is best adapted to the uses of business concerns with wide sectional or national interests, or to concerns that have a consistent month-to-month use for weather information. In addition, it should be kept in mind that nearly always there are changes in the local weather every few days, sometimes of a sudden and severe nature. Notice of these changes is widely disseminated up to 48 hours in advance in the local daily forecasts and in occasional warnings, both of which are essential as supplements to these Outlooks. In addition, extended forecasts from the National Meteorological Center should be consulted.

VOLUME 29, NUMBER 16
AUGUST 14, 1975

LONG RANGE PREDICTION GROUP, NATIONAL METEOROLOGICAL CENTER
WASHINGTON, D.C.

Figure 7.--The thirty-day outlook.

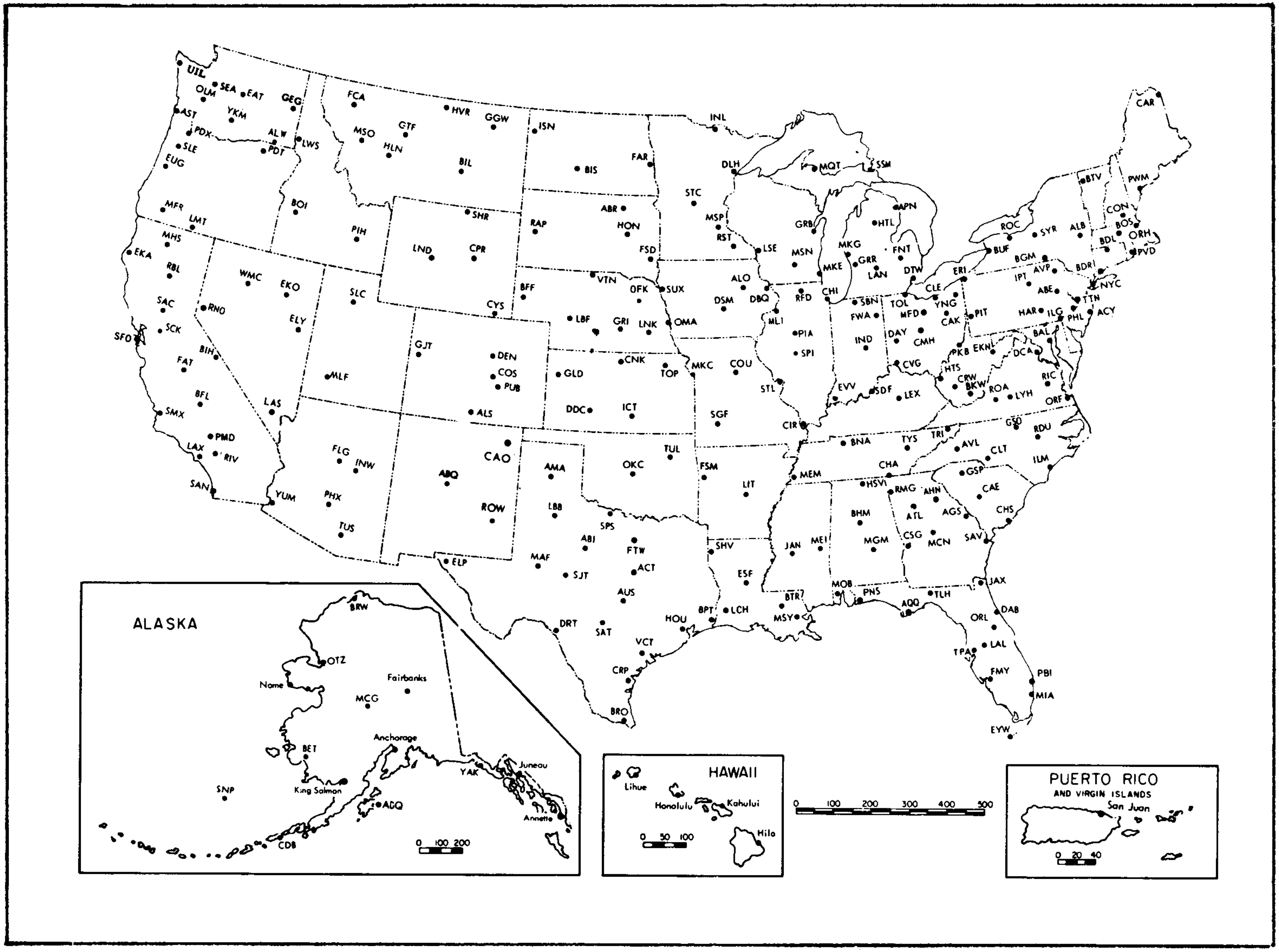


Figure 8.--NWS offices issuing local forecasts.

Transmisions can be received up to 60 miles from the antenna site, but the effective range depends on the terrain and type of receiver used. Where antennas are on hills or mountains, range may extend 100 miles or more. Broadcasts include local and area warnings and forecasts, radar summaries, current observations from surrounding towns and cities, including visibilities, sky conditions, and sea conditions where available. Radar summaries describe size of precipitation areas, speed of movement, and direction of movement. The weather radio broadcasts are on frequencies of 162.40 MHz and 162.55 MHz, and although a potentially valuable tool for field operations, their use is currently restricted by limited areas of coverage. To date, less than 20 percent of the country can receive transmissions. However, a large percentage of the Atlantic, Gulf, and Pacific Coasts and the Hawaiian Islands, is covered.

The limited coverage currently restricts use of NOAA weather radio broadcasts to NGS field projects in certain coastal or urban areas. The future potential for use of these broadcasts is excellent. Plans call for the current network of 77 broadcasting stations (appendix II) to be expanded to 128 stations by 1976 (appendix III) and to 331 stations by around 1980. This expansion will provide broadcast coverage for 90 to 95 percent of the Nation's population (fig. 9).[5] Since much of NGS field work is in or around the more densely populated sections of the country, most field projects would be able to receive transmissions. Expansion of weather radio coverage will make this source of weather information a valuable tool for all field parties.

Reliable radios that receive only NWS weather radio broadcasts may be purchased commercially at a price of 30 to 45 dollars.

IV. OFFICE USE OF CLIMATOLOGICAL INFORMATION

Climatological information can become a more useful tool in office planning of NGS field operations. The three levels of information (regional, state, and local) provide convenient sources of climatological information which can help in determining the occurrence of certain optimum weather conditions in specified areas. In some cases field projects cannot be planned with the aid of climatological data and must be accomplished with other job priorities in mind. Many jobs, however, can be planned with detailed knowledge of climatic elements taken into consideration.

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[5] Jensen, C. E., 1975: A Review of Federal Meteorological Programs for Fiscal Years 1965-1975. *Bulletin of the American Meteorological Society*, 56, (2), pp. 208-224.

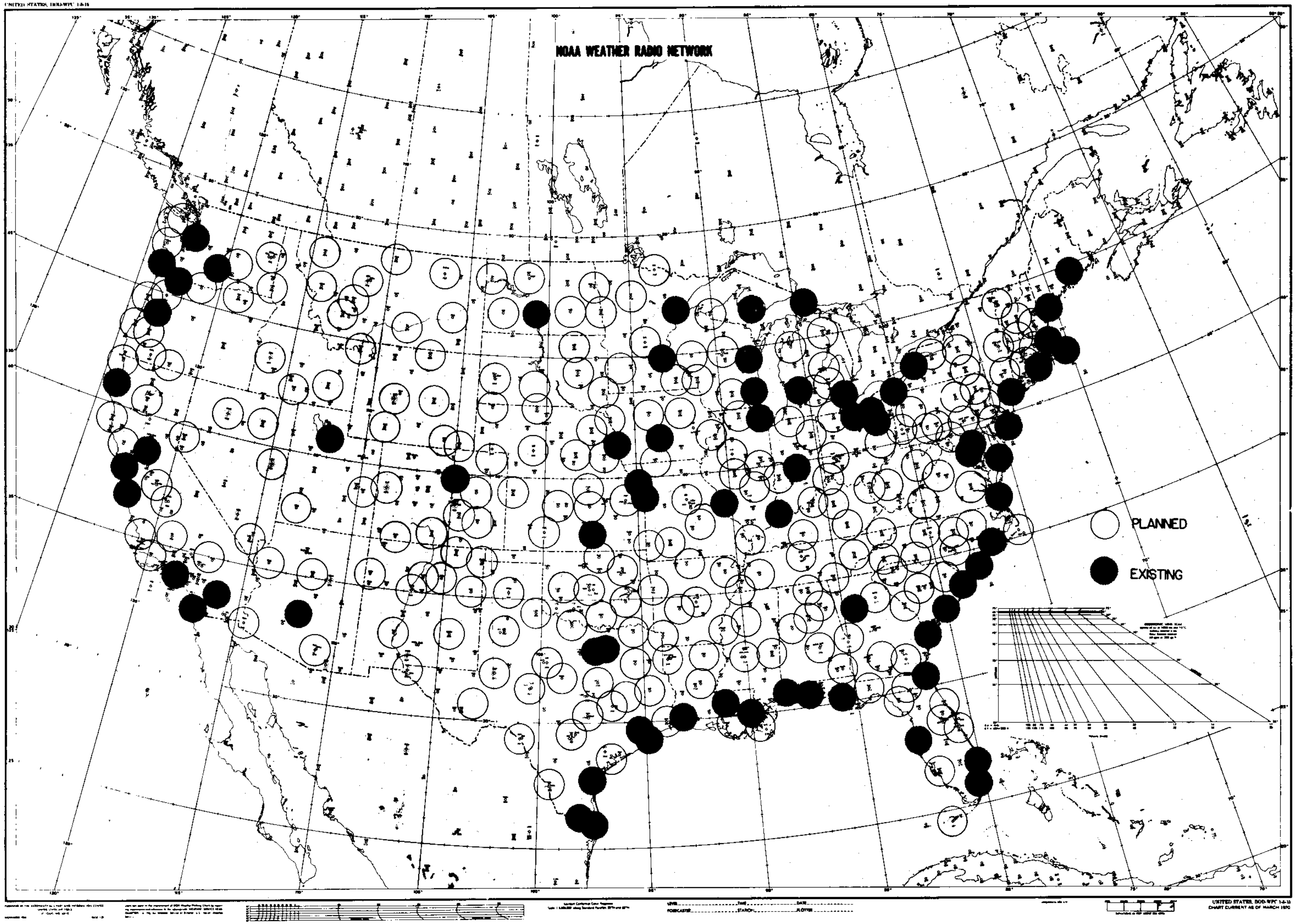

Figure 9. NOAA's weather radio network .

After the recommended sources of information are obtained for the office library, they can be used as a valuable means of decreasing the amount of delayed and lost field work. Once the area in which work is necessary has been determined, the climatic elements which will affect the type of work to be performed can be evaluated. Basic climatic characteristics and overall patterns affecting field work can be identified first on a regional level. Major weather-related problems may rule out job completion during specific months. If not, additional investigation at the state and local levels will lead to a more thorough knowledge of those times when optimum atmospheric conditions should prevail in the project area. The specific climatic elements of importance to the type of work being done (e.g., in horizontal control observations, visibility is of great importance) may be investigated using the *Summary of Hourly Observations*. Once knowledge of a specific element has been obtained, it may be applied. For example, a horizontal control project is being planned in Morgantown, West Virginia. It must be done in late summer and early fall. Information on visibilities for that area at that time of year indicates that 5 miles or less visibility prevails during most of that period. With this information at hand, the horizontal network could be set up to compensate for that fact. Lines of 10 and 12 miles would be avoided, where possible, and shorter lines of sight planned. Adjustment of distances between stations to fit prevailing visibilities is especially useful east of the Mississippi River where low visibilities (caused by haze and smog) are frequent during the summer months.

Using a combination of the three sources of climatological information, a reliable detailed picture of the average atmospheric conditions (of importance to NGS field operations) prevailing over most of the country can be constructed. It should be understood, however, that planning for future atmospheric conditions using climatological data (the only way available at present) assumes that the average weather conditions, which are statistically derived, will prevail. This is not always the case. Averages do not always prevail, and no climatological planning system initiated by NGS can completely eliminate delays and losses in work schedule caused by inclement weather. However, increased use of available climatological data in the office should substantially lower these weather-related delays and losses.

V. FIELD USE OF METEOROLOGICAL INFORMATION

Use of meteorological information should be more widespread in the field. Once a party is sent to an area, it usually remains until work is completed. Occasional inclement weather cannot be avoided, but knowledge of its probability of occurrence is of value to field party chiefs. Local conditions, which may vary appreciably within short distances, are also of importance to field operations. Weather (especially in hilly or mountainous terrain) at a station 25 miles from base camp may be totally different from that occurring at the camp. Supervisory field personnel should be aware of the locations of the nearest NWS field offices in their area, and telephone numbers and addresses of these offices should be supplied as necessary (numbers are not always listed and are not for general public use).[6] Communication, either in person or by telephone, with these offices can lead to a better awareness of present and possible future atmospheric conditions, which will enable field personnel to incorporate weather into their planning and thus make operations somewhat less susceptible to adverse weather conditions. Again, meteorological data and forecasts are not foolproof. Errors in forecasting do occur, but short-range forecast accuracies are reliable enough to warrant their use.

VI. FUTURE CLIMATIC OBJECTIVES FOR OFFICE PLANNING

The preceding discussion about the use of weather data has centered around individual studies of climatic patterns and elements. This requires that extra time be spent on each field project planned in the future. As more and more planning incorporates climatic information, it will be found that the same areas will be investigated more than once. Nevertheless, this method of climatic planning could be useful until a more effective permanent plan is developed.

An effective permanent solution for combining important climatological data to be used by the NGS Program Planning Unit would be the creation of maps similar to figure 10, which is an isoline map for use in horizontal control planning. A series of these maps could be produced from base maps of various climatological factors. There would be one map per month for each type of operation concerned. Through the use of isolines, the maps would depict the number of days in each of the 12 months in which work could progress with little or no interruption. There would be 7 isolines per monthly map, each representing a 5-day interval (0 to 30). For example, a January map for horizontal control (fig. 10) might illustrate a 0 (zero) day line running from Maine, across the Great Lakes, through South Dakota, and through Montana into Canada. North of this line, work would either be interrupted frequently or lost (given limits illustrated in table 1 for specific climatic elements which restrict operations) for all days of the month. The 25-day line might run across the southern tier of states. South of this line, the

[6] NWS headquarters can furnish lists of these phone numbers.

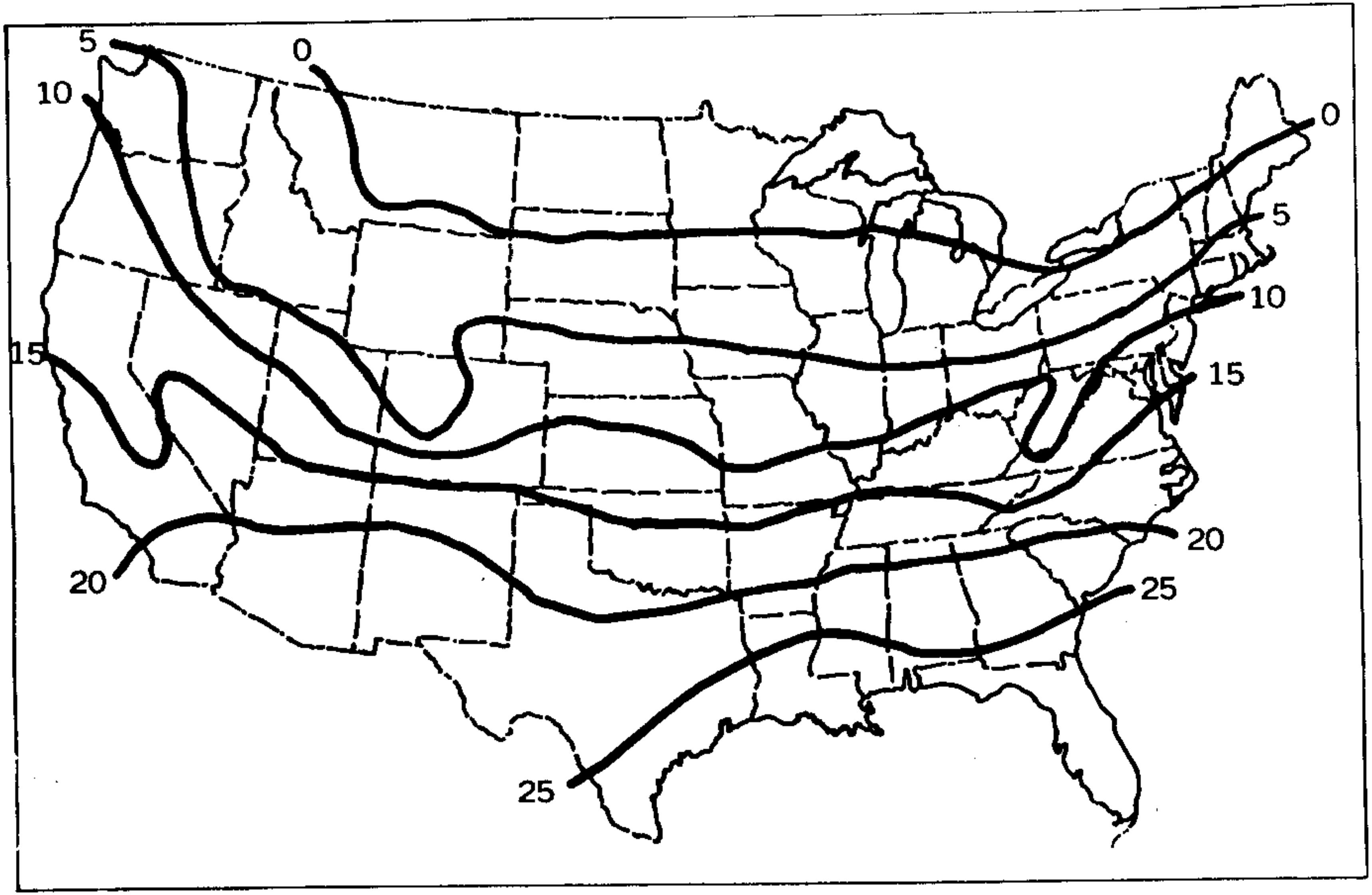

Figure 10. A simulated isoline map for use in horizontal control planning (see text).

weather on more than 25 days in an average January would permit relatively uninterrupted work to progress. The other isolines at 5-day intervals between the two described lines would add further detail.

To produce such a series of maps, climatic elements that restrict operations would first have to be combined in some fashion. A possible method for the determination of this combination could be the creation of some type of mathematical relationship between the relevant climatic elements affecting operations. NWS and EDS personnel should be contacted to determine the feasibility of this approach. If a mathematical function of this type could be developed, data from stations across the country could be used to arrive at a numerical solution. The results could then easily be plotted to produce the desired isoline maps.

VII. SUMMARY

A. Office Use of Climatic Information

Sources of Climatic Information for NGS Program Planning Unit:

Climatic Atlas of the United States--illustrates regional patterns of climatic elements by isoline maps.

Climates of the States--narrative guide to climatic conditions on a state level.

Summary of Hourly Observations--detailed local data on precipitation, sky cover, visibility, and wind speed, available for 150 stations nationally.

Climatological Substation Summaries--narrative and tabular guide to local climatic conditions, available for approximately 1200 stations.

All of the above are available from the National Climatic Center, Asheville, North Carolina.

Procedures for Use of Climatic Data in Office:

Short-term basis. Examine overall regional climatic patterns, identify any large-scale problems in field project area.

Focus on more specific geographic region at state level if regional elements indicate field work is feasible.

Determine exact information and data on important elements at local level.

Combine all information and data to determine general time periods when optimum working conditions would most likely occur.

Plan (where possible) time for field project to start.

Long-term basis. Develop set of monthly maps, depicting the number of days per month (assuming average weather conditions) that work could progress relatively uninterrupted by weather.

An individual set of monthly maps for each type of field operation, horizontal control, vertical control, and astronomy, will be developed.

Development of maps could possibly be accomplished by the creation of a mathematical relationship (function) between atmospheric variables and the requirements for field operations. Numerical solutions would be graphed to form isoline maps. NWS would be the local group to develop the mathematics for this task.

B. Field Use of Meteorological Information

Types of Information Available:

"FT" terminal forecasts: ceiling and visibility forecasts 3 times daily--12 hours into future.

Detailed information on present and future weather conditions; specific questions and problems concerning weather may be discussed. Available from NWS stations.

Sources of Information:

260 NWS weather stations; at least one per state; many operate 24 hours per day.

NWS continuous weather radio broadcasts (some locations).

Ways to Obtain Information:

Personal contact with weather offices in area of field project from addresses supplied to party chief.

Telephone contact with closest regional NWS forecast offices. Telephone numbers should be supplied to party chief.

Use of weather radio broadcasts.

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National Weather Service, 1974: *Operations of the National Weather Service.* U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, MD, 255 pp.

National Weather Records Center, 1969: Key to meteorological records documentation, no. 4.11, *Selective Guide to Climatic Data Sources.* U. S. Department of Commerce, Environmental Science Services Administration (now NOAA), Washington, D. C., 94 pp.

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APPENDIX I. Available sources of climatological information

Climatic Atlas of the United States, National Climatic Center, Federal Building, Attention: Publications, Ashville, N. C. 28801. Price: $6.00.

Climates of the States (2 volumes), Water Information Center, Inc., Port Washington, N. Y. 11050. Price: $39.50.

Summary of Hourly Observations, Series no. 30, and Series no. 82. National Climatic Center, Federal Building, Attention: Publications, Ashville, N. C. 28801. (Request complete set of all in-print summaries, 5 or 10 years, available for 48 states.) Price: Varies with number of in-print summaries.

Climatology Substation Summaries, Climatography No. 20, National Climatic Center, Federal Building, Attention: Publications, Ashville, N. C. 28801. (Request complete set of in-print summaries, new where available, otherwise old.) Price: Varies with number of in-print summaries.

The National Climatic Center also has a quick response telephone information center which can be reached on:

FTS: 672-0683
Commercial: 704-258-2850, extension 683
Direct dial, D.C. area only: 427-7919

APPENDIX II. Cities in which NOAA weather radio broadcast stations are currently in operation (July 1, 1975).

ALABAMA
- Mobile

ALASKA
- Anchorage
- Seward

ARIZONA
- Phoenix

CALIFORNIA
- Coachella
- Eureaka
- Los Angeles
- Monterey
- Sacramento
- San Diego
- San Francisco

COLORADO
- Denver

CONNECTICUT
- New London

FLORIDA
- Jacksonville
- Miami
- Panama City
- Pensacola
- Tampa
- West Palm Beach

GEORGIA
- Atlanta
- Savannah

HAWAII
- Hilo
- Honolulu
- Kokee
- Mt. Haleakala

ILLINOIS
- Chicago

INDIANA
- Indianapolis
- Evansville

IOWA
- Des Moines

KANSAS
- Wichita

LOUISIANA
- Baton Rouge
- Lake Charles
- New Orleans

MAINE
- Ellsworth
- Portland

MARYLAND
- Baltimore
- Salisbury

MASSACHUSETTS
- Boston
- Hyannis

MICHIGAN
- Detroit
- Grand Rapids
- Sault Ste Marie

MINNESOTA
- Duluth
- Minneapolis

MISSOURI
- Kansas City
- St. Joseph
- St. Louis

NEW JERSEY
- Atlantic City

NEW YORK
- Buffalo
- New York
- Rochester

NORTH CAROLINA
- Hatteras
- New Bern
- Wilmington

OHIO
- Akron
- Sandusky
- Cleveland

OREGON
- Astoria
- Eugene
- Portland

PENNSYLVANIA
- Erie

SOUTH CAROLINA
- Charleston
- Myrtle Beach

TEXAS
- Brownsville
- Corpus Christi
- Dallas
- Ft. Worth
- Galveston
- Houston
- Pharr

Utah
- Salt Lake City

VERMONT
- Burlington

APPENDIX II. (Continued)

<u>VIRGINIA</u>
Manassas (Wash., D.C. area)
Norfolk

<u>WASHINGTON</u>
Seattle

<u>WISCONSIN</u>
Green Bay
Milwaukee

APPENDIX III. Cities to be added to the current NOAA weather radio broadcast network in 1975-1976.

CALIFORNIA
- Crescent City
- Fresno
- Fort Bragg
- San Luis Obispo
- Santa Barbara
- Santa Rosa

CONNECTICUT
- Hartford

FLORIDA
- Cross City
- Daytona Beach
- Fort Myers
- Key West
- Melborne
- Tallahassee

INDIANA
- Evansville
- Fort Wayne
- South Bend
- Terre Haute

LOUISIANA
- Buras
- Morgan City
- Shreveport

MASSACHUSETTS
- Worcester

MICHIGAN
- Alpena
- Bay City
- Flint
- Ironwood
- Lansing
- Traverse City

NEW YORK
- Albany
- Rochester
- Syracuse

NORTH CAROLINA
- Cape Hatteras

OHIO
- Cincinnati
- Dayton

OKLAHOMA
- Oklahoma City
- Tulsa

OREGON
- Coos Bay
- Newport

PENNSYLVANIA
- Allentown
- Harrisburg
- Philadelphia
- Pittsburgh
- Scranton

SOUTH CAROLINA
- Columbia

TENNESSEE
- Nashville

TEXAS
- Port Lavaca

VERMONT
- Burlington

VIRGINIA
- Richmond

WASHINGTON
- Hoquiam
- Port Angeles
- Yakima

WISCONSIN
- Madison