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**A Climatological Study of the
AFGL Mesonetwork
Volume I**

H. ALBERT BROWN

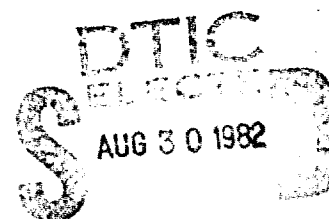
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20. Abstract (continued)

In the final section, the climatology derived from one year of data for half of the stations is presented. Selection of stations was based on topographic features or location in the network. Sites represented are located at towers, runways, swamps, valleys, hills and, finally, at the coast line.

The climatology includes extinction coefficient, and wind direction and speed. Cumulative frequency curves rank the stations according to frequency of visibility restrictions and wind speeds. Highest frequencies of visibility restriction were observed at the hill sites, lesser frequencies at coastal sites, runway sites and, finally, the lowest frequencies at the valley sites. Highest frequencies of high wind speeds occurred at the hill and coastal sites. The valley sites, due mainly to the sheltering effect of surrounding topography, showed the lowest frequencies.

Diurnal variations of extinction coefficient and wind speed throughout four months representative of the four seasons are graphed. Strong diurnal variation of visibility with nocturnal maxima in fall and summer are shown. The effects of coastal fog in June were quite apparent. Strong diurnal variation of wind speed was apparent for all seasons.

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Preface

The efforts of Mrs. Maureen Hampton and Mrs. Joan Ward, Systems and Applied Sciences Corporation, in the formulation of the data-editing and climatology programs are gratefully acknowledged. Many individuals from the Air Force Geophysics Laboratory assisted in the program; in particular, Captain Edward B. Geisler assumed the editing responsibility for a three-month period during the author's absence. In addition, the author is most grateful to Mr. Donald Chisholm and Dr. Stuart Muench for many valuable discussions concerning the study, and especially to Mr. Chisholm for many helpful comments on the paper itself. The author also wishes to acknowledge the assistance of Mrs. Alysia Pelletier in typing the manuscript.

A Climatological Study of the AFGL Mesonet, Volume I

1. INTRODUCTION

From 1972 to 1976, the Air Force Geophysics Laboratory (AFGL) conducted an experimental program to explore the benefits that could be achieved in short-range (0-3 hours) forecasting from the use of automated weather observations.¹ To accomplish this goal, a field test facility was established in the eastern part of Massachusetts. It consisted of 25 surface weather stations and one instrumented tower. The network was under the control of a computer located at Hanscom Air Force Base, Massachusetts, and automated techniques were utilized to acquire, process, display, and archive the data for use in real-time, short-range forecasting experiments, and for the development of objective mesoscale prediction and analysis techniques.

The forecasting experiments² were conducted as a competition between forecasters. One forecaster based his forecasts on conventional weather data only, while the other forecaster was allowed to use both conventional and mesoscale

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1. Hering, W. S., Brown, H. A. and Muench, H. S. (1972) Mesoscale Forecasting Experiment, Bull. Am. Meteorol. Soc., **53**, 12:1180-1183.
2. Hering, W. S. and Quick, D. L. (1974) Hanscom visibility forecasting experiments, Proc. 5th Conf. on Weather Forecasting and Anal., pp. 224-227.

data. The forecasters who had access to the more detailed data were found to be more skillful (about 10-15 percent) than those who relied on conventional data alone.

Further studies³⁻⁵ revealed the time and space characteristics of visibility in fogs and advective weather patterns. Objective techniques were also developed to aid the forecaster in the use of the complex and voluminous mesoscale data in his forecasting efforts.

Since visibility was recognized to be one of the most significant operational aviation weather parameters, emphasis was placed on it throughout the forecasting experiments. In order to carry out these experiments, however, a full complement of weather sensors was established at each station. The basic instrumentation at each site observed visibility, wind direction, wind speed, temperature, and dewpoint.

This represents the first step in the development and analysis of an edited mesoclimatological data base of the four years of observations by the 26 automated weather stations. In Volume I, the first section will describe the station network that existed between 1972 and 1976, the weather instruments, and the methodology of the data-editing routine. In the final section, the mesoclimatology derived from one year of data, for half the stations, will be presented. In Volume II, a five-part statistical summary of surface weather observations collected by the thirteen stations during the one-year period will be documented.

2. SURFACE NETWORK

In planning the layout of the new network, it quickly became apparent that a circular network surrounding Hanscom Air Force Base to the distance required would be prohibitively expensive. The final plan called for the establishment of an elliptical-shaped network beginning at Hanscom Air Force Base and extending to the northeast to Hampton, New Hampshire. The density of the network stations was greatest in the southwest, near Hanscom, and least in the northeast. This

3. Chisholm D. A. and Kruse, H. (1974) The Variability of Visibility in the Hanscom Mesonet: A Preliminary Assessment, AFCRL-TR-74-0265, AD784791.
4. Tahnk, W. R. (1975) Objective Prediction of Fine Scale Variations in Radiation Fog Intensity, AFCRL-TR-75-0269, ADA014774.
5. Chisholm, D. A. (1976) Objective Prediction of Mesoscale Variations of Sensor Equivalent Visibility During Advective Situations, AFGL-TR-76-0132, ADA030332.

rational, allowed forecasting for Hanscom Air Force Base in those situations with weather systems propagating to the southwest (i.e., winter "nor'easter") from the coast. On the other hand, if weather systems moved in from the southwest, provision was made to forecast for one of the sites near Hampton, New Hampshire. Careful consideration was also given to specific site locations in order to determine the detailed behavior of mesoscale weather systems under a variety of topographical settings. Thus, individual stations were positioned on hilltops, in valleys, on flat meadows, along the seaside, and in swampy lowlands.

The network of stations established during the four-year period is shown in Figure 1. Two network configurations are illustrated in the figure. The first

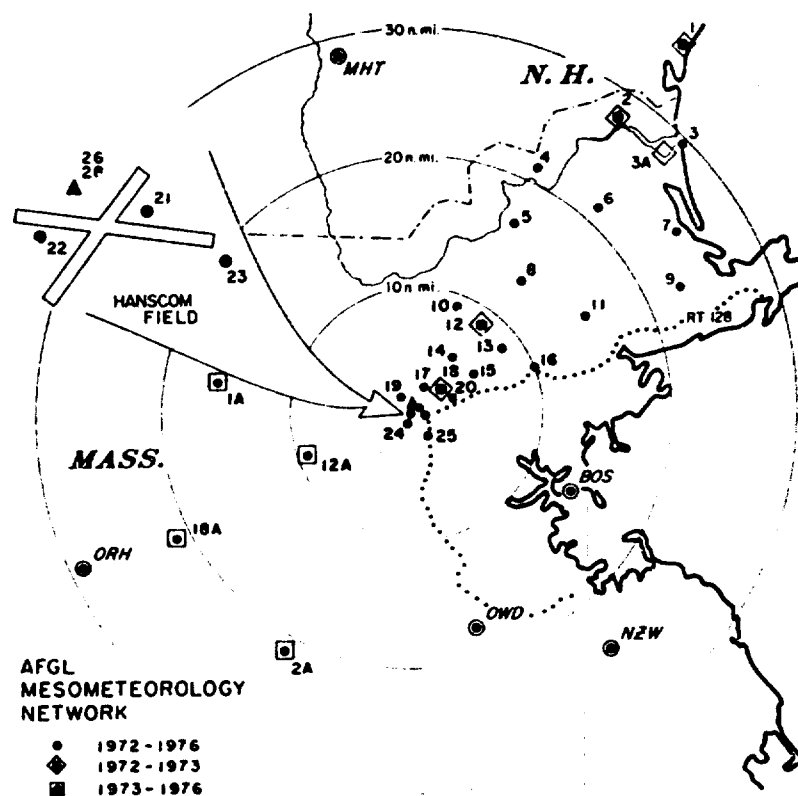


Figure 1. Network of Remote Surface Weather Stations. An enlarged view of Hanscom Air Force Base shows the runway (solid circles) and tower (solid triangle) locations

network, denoted by dots and diamond-dots, located to the northeast of Hanscom Air Force Base, was operated between Fall 1972 and Spring 1973. During this period, the forecasting experiments revealed that storm systems traveling from the northeast at relatively slow speeds could be tracked adequately with fewer stations. During the same period, weather systems traveling from the southwest, at a much higher speed and frequency than expected, highlighted a need to extend the network to the southwest. A decision was made, therefore, to close four stations to the northeast of Hanscom and relocate them to the southwest, as denoted in Figure 1 by square-dots. Except for the minor relocation of the Plum Island site (PLM-3 to PLM-3A), the second configuration was maintained until the completion of the project. Station particulars, e. g., call letters and numbers, latitude, longitude and ground elevation, are listed in Table 1. Topographical charts of the area surrounding each station are shown in Appendix A.

Table 1. Mesonetwork Station Identification and Location

STATION IDENT.			LOCATION		ELEVATION	Date Collection Began	SITE
NO.	CALL LTR.	NAME	LAT	LONG	Meters		
1	HMP	Hampton, NH	42 55'25"	70 49'00"	2	4 Sept 1972	Coastal
2	AMS	Amesbury, MA	42 51'15"	70 56'15"	87	4 Sept 1972	Hill
3	PLM	Plum Island, MA	42 49'00"	70 49'00"	3	4 Sept 1972	Coastal
4	HAV	Haverhill, MA	42 47'20"	71 04'08"	49	4 Sept 1972	Hill
5	LAW	Lawrence, MA	42 42'55"	71 07'10"	50	4 Sept 1972	Runway
6	GEO	Georgetown, MA	42 44'10"	70 07'10"	23	4 Sept 1972	Valley
7	NIP	North Ipswich, MA	42 43'00"	70 50'40"	17	4 Sept 1972	Coastal
8	BSH	Andover, MA-Bos Hill	42 18'50"	71 05'40"	114	4 Sept 1972	Hill
9	SAG	Sagamore Hill, MA	42 37'50"	70 48'55"	56	4 Sept 1972	Hill
10	TWK	Tewksbury, MA	42 36'45"	71 12'55"	35	4 Sept 1972	Valley
11	MID	Middleton, MA	42 35'55"	70 59'10"	64	4 Sept 1972	Hill
12	AVC	Wilmington, MA-AVCO	42 15'35"	71 09'15"	47	4 Sept 1972	Hill
13	HAC	Reading, MA-P.S.	42 13'05"	71 08'00"	23	4 Sept 1972	Swamp
14	BIL	Billerica, MA	42 32'40"	71 13'10"	32	4 Sept 1972	Valley
15	CHS	Wilmington, MA-P.S.	42 31'45"	71 10'15"	27	4 Sept 1972	Valley
16	CCG	Camp Curtis Guild	42 31'45"	71 04'40"	30	4 Sept 1972	Valley
17	VAH	Bedford, MA-VA Hosp.	42 30'20"	71 16'10"	38	4 Sept 1972	Valley
18	MTR	Bedford, MA-MITRE	42 30'10"	71 14'10"	38	4 Sept 1972	Valley
19	NKE	Bedford, MA-Nike Site	42 29'25"	71 18'15"	49	4 Sept 1972	Hill
20	RKO	Burlington, MA-P.S.	42 29'15"	71 13'10"	40	4 Sept 1972	Swamp
21	NRV	Hanscom N Runway	42 28'20"	71 17'05"	38	4 Sept 1972	Runway
22	WRV	Hanscom W Runway	42 28'15"	71 17'55"	38	4 Sept 1972	Runway
23	ERV	Hanscom E Runway	42 28'05"	71 16'10"	38	4 Sept 1972	Runway
24	DMP	Hanscom Landfill	42 27'35"	71 18'05"	41	4 Sept 1972	Swamp
25	DPW	Lexington, MA	42 26'30"	71 15'35"	53	4 Sept 1972	Valley
26	TWL	Hanscom Tower (lower)	42 28'35"	71 17'40"	43	4 Sept 1972	Tower
28	TWH	Hanscom Tower (upper)	42 28'35"	71 17'40"	43	4 Sept 1972	Tower
1A	DEV	Fort Devens, MA	42 30'40"	71 38'10"	79	14 June 1973	Plateau
2A	MIL	Milford, MA	42 09'20"	71 30'55"	84	31 Aug 1973	Valley
3A	PLM	Plum Island, MA-APT	42 47'45"	70 50'10"	2	20 June 1974	Coastal
12A	SUD	Sudbury, MA	42 25'08"	71 28'32"	64	9 June 1973	Valley
18A	SHR	Shrewsbury, MA	42 18'45"	71 42'35"	165	27 June 1973	Valley

3. STATION INSTRUMENTATION

An example of an automated weather station (WRY-22) is shown in Figure 2. The instruments at the three runway stations (21, 22, and 23) were mounted on

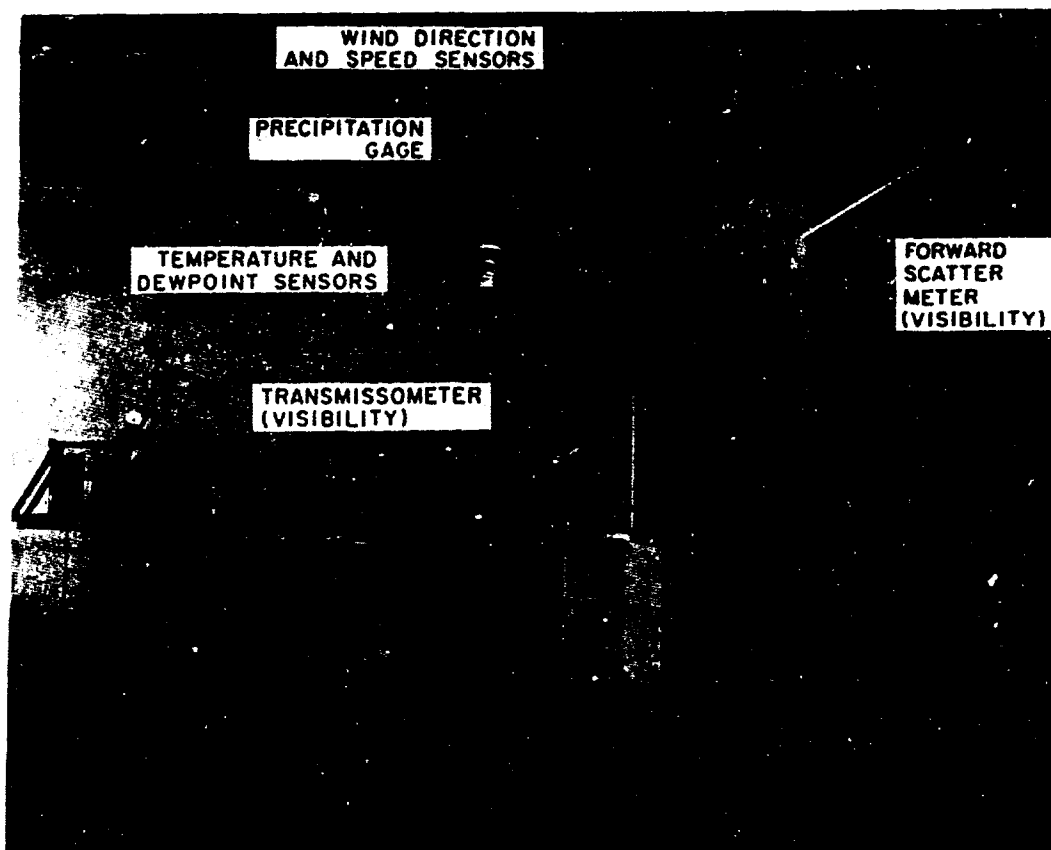


Figure 2. Picture of Station (WRY) Showing the Mesonetwork Weather Instruments (Visibility, Wind, Precipitation and Temperature-Dewpoint) and the Transmissometer

cross arms at a height of 4 m. The remaining stations had instruments mounted at a height of 8 m. The tower (26-28) was instrumented at two levels, 30 and 45 m.

All stations were equipped with sensors that reported wind direction, wind speed, visibility, temperature, and dewpoint. In addition, ten stations were equipped with heated precipitation gauges, while four were augmented with transmissometers.

The temperature-dewpoint instrument (EG&G 110S-M) utilized a thermo-electrically cooled mirror with optical sensing of the liquid or frozen condensate. The temperature and dewpoint measurements were obtained with platinum-resistance thermometers that sensed the temperature of the condensate surface and the ambient air. Temperature range of the instrument was from -80° to 120° F with an accuracy of $\pm 0.5^{\circ}$ F.

The wind set (Climatronics WM-1) was relatively new on the market when it was acquired for the mesonetwork. Special features of the cup and vane set, which made it desirable for our use, were low start speed, fast response, and a friction-free transducer for sensing wind direction.

The instrument used to determine visibility (EG&G 207 Forward-Scatter-Meter) was developed under AFGL contract. Its special features were single-unit construction, short-path-length, and good agreement with conventional larger sample volume visibility instruments. The set had the ability to determine visibility over a range of 70 m to 7000 m. More detailed discussion on the forward scatter meter may be found in other studies.⁷⁻⁹

The precipitation and transmissometer data were not included in the climatological study. The rationale for operation of the transmissometers was merely to provide consistency checks with the forward-scatter-meters (FSMs) in the early stages of the project, under widely varying visibility conditions. After a very short time, the reliability of the FSMs was such that these checks were dispensed with. The inclusion of the transmissometer would, therefore, only provide redundant information.

In the case of precipitation gauges, considerable noise, generated by spurious counts of the instrument in response to wind gusts, noisy data lines, and cycling of the heating mechanism, rendered the data unsuitable for analysis.

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7. Muench, H. A., Moroz, E. Y. and Jacobs, L. P. (1974) Development and Calibration of the Forward Scatter Visibility Meter, AFCL-TR-74-0145, AD783270.
 8. Chisholm, D. A. and Jacobs, L. P. (1978) An Evaluation of Scattering-Type Visibility Instruments, AFCL-TR-75-0411, ADB010224L.
 9. Brown, H. Albert (1979) Preliminary Assessment of an Automated System for Detecting Present Weather, AFGL-TR-79-0137, ADA078031.

The mesonet magnetic tapes are the basic building blocks of the mesoclimatology data base. Each tape contains approximately three days of data. During the operating period of the mesonet, from 1972 to 1976, 420 tapes were generated. It took 10 seconds for the Honeywell 324 computer (used to operate the mesonet) to query all sensors at all the stations. Thus, every sensor was sampled six times per minute. It was decided to edit each tape and generate one-minute averages of all the variables with the corrected data. This information could be stored on a master magnetic tape and achieve a reduction factor of about 10, which would greatly facilitate the use of the data in time and space variability studies. At the same time, a mesoclimatology of the network could be generated.

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generated by the program for each tape processed. It summarizes, generally, in hourly increments, the meteorological observations for each station. On the upper left, the first line gives month, day, and year (e.g., 120 1973 denotes January 20, 1973). TIME indicates the hour or portion of the hour (GMT) for the following calculations:

- ID - Station number and station call letter (see Table 1).
- N - Number of 6-second data points in the temperature, dewpoint, wind direction, wind speed, and visibility averages.
- N1 - Number of one-minute averages that made up the subsample average.
- TT - Average temperature value (in 0.1°F) for the time interval noted.
- ST - Standard deviation of temperature. (0.1°F)
- TD - Average dewpoint value (in 0.1°F) of the time noted.
- STD - Standard deviation of dewpoint (0.1°F).
- DD - Vector mean wind direction (degrees) for the time interval noted.
- FF - Vector mean wind speed (0.1 knots) for the time interval noted.
- SCM - Scalar mean wind speed (0.1 knots) for the time interval noted.
- DX - One-minute average wind direction at time of maximum one-minute average speed.
- FX - Maximum one-minute average wind speed during time interval sampled.
- SV - Vector Standard Deviation of wind (0.1 knot).
- EXCO - Average extinction coefficient (in 10^{-4}m^{-1}) for the time interval noted.
- EMX - The maximum one-minute average extinction coefficient ($\times 10^{-4}\text{m}^{-1}$) observed during the time interval.
- SDE - The standard deviation of the extinction coefficient.

With this output, it is possible to edit each station's complement of instruments rapidly, on an hour-to-hour and daily basis. In this particular figure, the temperature and dewpoint appears to be operating satisfactorily throughout the day. Columns headed by N and N1 indicate that sixty minutes of data are being collected in each hour, and that almost all one-minute averages are based on six samples.

The wind direction and speed (DD and FF) also appear to be operating satisfactorily, and sixty minutes of data are represented in the hourly average, but there are fewer than the maximum data points (N) being collected each hour. This is undoubtedly due to a noisy channel causing some data to have been rejected by the mesonetwork computer. The columns headed DX and FX show that the period began with high winds (20-26 knots) from the northwest that decreased during the day to about 4-6 knots from the west to southwest. The visibility meter

Figure 4 shows the second form of output from the initial editing program. It follows the individual station outputs and gives a summary, by day, of all the

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stations. Column headings are the same except that N1 denotes the number of hours that data were available during the period. This particular output is for January 21, 1973. The station numbers and call letters are listed in sequence and it becomes an easy task to scan each column (TT, TD, DD, FF, and EXCO) and compare daily averages. Inoperative or malfunctioning sensors are thus quickly determined. In the temperature column, TT, stations 21 (NRY), 23 (ERY), 26 (TWL), and 28 (TWH) report values that indicate the temperature sensors were not operating properly and, therefore, should be suppressed. The dewpoint column, TD, shows malfunctions or inoperative sensors at stations 19, 21, 23, 25, 26, and 28. The wind direction and speed columns, DD and FF, show suspicious average wind data at stations 2, 18, 26, and 28. Reference to the individual outputs for each station resulted in these data being deleted. Finally, a check of the visibility data, EXCO, revealed that all stations were reporting unlimited visibility and valid measurements during this day.

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-60	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
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Figure 5. Editing Output Illustrating the Frequency Distribution of One-Minute Average Wind Directions for all Mesonetwork Stations in 10° Wind Direction Categories for the Period 2240 GMT, January 20 Through 1323 GMT, January 24, 1973

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000
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11 126/2240- 126/1333

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	HNP	ANS	PLN	MW	LAW	GE	NTP	DSH	SAG	THK	NIO	AVC	HAC	STL	CHT	CCG	WAM	MTR	HRF	RKO	HRV	HRV	HRV	HRV	HRV	HRV	HRV	
15-0000-15	1																											
15-0000-10	2																											
15-0000-5	3																											
15-0000-0	4																											
15-0000-10	5																											
15-0000-15	6																											
15-0000-20	7																											
15-0000-25	8																											
15-0000-30	9																											
15-0000-35	10																											
15-0000-40	11																											
15-0000-45	12																											
15-0000-50	13																											
15-0000-55	14																											
15-0000-60	15																											
15-0000-65	16																											
15-0000-70	17																											
15-0000-75	18																											
15-0000-80	19																											
15-0000-85	20																											
15-0000-90	21																											
15-0000-95	22																											
15-0000-100	23																											
15-0000-105	24																											
15-0000-110	25																											

Figure 7. Editing Output Illustrating the Frequency Distribution of One-Minute Average Temperatures ($^{\circ}\text{F}$) for all the Mesonetwork Stations for the Period Noted in Figure 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	HNP	ANS	PLN	MW	LAW	GE	NTP	DSH	SAG	THK	NIO	AVC	HAC	STL	CHT	CCG	WAM	MTR	HRF	RKO	HRV	HRV	HRV	HRV	HRV	HRV	HRV	
15-0000-15	1																											
15-0000-10	2																											
15-0000-5	3																											
15-0000-0	4																											
15-0000-10	5																											
15-0000-15	6																											
15-0000-20	7																											
15-0000-25	8																											
15-0000-30	9																											
15-0000-35	10																											
15-0000-40	11																											
15-0000-45	12																											
15-0000-50	13																											
15-0000-55	14																											
15-0000-60	15																											
15-0000-65	16																											
15-0000-70	17																											
15-0000-75	18																											
15-0000-80	19																											
15-0000-85	20																											
15-0000-90	21																											
15-0000-95	22																											
15-0000-100	23																											
15-0000-105	24																											
15-0000-110	25																											

Figure 8. Editing Output Illustrating the Frequency Distribution of One-Minute Average Dewpoints ($^{\circ}\text{F}$) for all the Mesonetwork Stations for the Period as in Figure 5

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	HNP	ANS	PLN	MW	LAW	GE	NTP	DSH	SAG	THK	NIO	AVC	HAC	STL	CHT	CCG	WAM	MTR	HRF	RKO	HRV	HRV	HRV	HRV	HRV	HRV	HRV	
15-0000-15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-10	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-5	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-0	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-10	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-15	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-20	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-25	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-30	9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-35	10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-40	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-45	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-50	13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-55	14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-60	15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-65	16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-70	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-75	18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-80	19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-85	20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-90	21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-95	22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-100	23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-105	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15-0000-110	25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

Figure 9. Editing Output Illustrating the Frequency Distribution of One-Minute Average Extinction Coefficients ($\times 10^{-4} \text{ m}^{-1}$) for all the Mesonetwork Stations for the Same Period as in Figure 5

In the case of wind direction, Figure 5, one-minute average values are categorized in 10° intervals. The bottom line, 37, contains the frequency count of calm conditions. Scanning this table provides additional insight into an examination of the consistency and validity of the wind-direction sensors. For example, Station 2-A shows an unusually high, and unrealistic, count of wind-direction occurrences between 10 and 20° , 110 and 120° , and 310 and 330° . This lends support to the discrepancy noted in Figure 4 for the same station, and gives further justification to the determination that the wind-direction sensor was malfunctioning. The same rationale is used to suppress the data for station 18-MTR, which shows an unrealistic number of occurrences in the 1 to 10° wind-direction range, Station 28-TWH, which has too high a count in the 230 to 240° range, and, finally, Station 26-TWL, which shows most winds were calm.

Figure 6 shows the frequency distribution of one-minute average wind speeds for each station. The rows are identified with the appropriate wind-speed categories (knots) while the columns are titled with each station number and call letter. A scan of the frequency distributions shows a physically consistent shift to higher speeds at the hilltop, tower, and coastal locations (2-AMS, 3-PLM, 11-MID, 19-NKE, and 28-TWH). The very large number of calms at station 26-TWL also verifies the malfunctioning of that sensor.

The frequency distribution of one-minute temperature values is shown in Figure 7. The caption in the upper left denotes the time interval included in this tape, January 20, 2240 GMT to January 24, 1333 GMT. The columns are labeled with station number and call letters, while the rows give the temperature categories ($^\circ\text{F}$). It is apparent that several of the stations (1, 2, 5, and 25) have reported several observations that are out of normal range, and do not appear valid. A later figure, Figure 10, will show how these individual readings are catalogued and identified for editing. The temperature set at Station 8-BSH appears to have a major problem and is a candidate for complete deletion.

Figure 8 shows the frequency distribution of one-minute average dewpoint values. Columns and rows are the same as in Figure 7. The dewpoint sensors appear to generate noisier data than the temperature sensors. Stations that are candidates for elimination because of malfunctioning sensors are 2, 8, 12, 17, and 19. The remainder of the stations can be retained after editing out the individual minutes that lie outside the expected ranges.

The one-minute average values of extinction coefficient, Figure 9, are the most difficult to edit. The range of the visibility values from $0 \times 10^{-4} \text{ m}^{-1}$ to $500 \times 10^{-4} \text{ m}^{-1}$, when combined with the sometimes local nature of visibility restrictions, allows for wide variations between stations. At the same time, some visibility restrictions have very short lifetimes. We have found that examination of the time variation of visibility at a single location (see Figure 3) provides the

best means for determining the validity of a forward-scatter-meter's measurements. It should be noted that this frequency distribution, Figure 9, represents data that was collected between January 20, 2240 GMT, and January 24, 1333 GMT. Re-examination of the daily records for each station showed that on January 23 no extinction coefficients were recorded for a short period of time at most of the stations.

Figure 10 is a representative section of the last output of the editing program. This section of the program lists, chronologically and by station, those one-minute

	TT	TD	WS
WSP OUT OF RANGE 73 1207768 WSP 17			217
WSP OUT OF RANGE 73 1207767 WSP 17			243
WSP OUT OF RANGE 73 1207766 WSP 17			246
WSP OUT OF RANGE 73 1207765 WSP 23			241
WSP OUT OF RANGE 73 1207764 WSP 0			244
WSP OUT OF RANGE 73 1207763 WSP 10			251
WSP OUT OF RANGE 73 1207762 WSP 12			145
WSP OUT OF RANGE 73 1207761 WSP 1			
WSP OUT OF RANGE 73 1207760 WSP 1			
WSP OUT OF RANGE 73 1207759 WSP 1			
WSP OUT OF RANGE 73 1207758 WSP 10			252
WSP OUT OF RANGE 73 1207757 WSP 25			240
WSP OUT OF RANGE 73 1207756 WSP 27			247
WSP OUT OF RANGE 73 1207755 WSP 24			241
WSP OUT OF RANGE 73 1207754 WSP 0			240
WSP OUT OF RANGE 73 1207753 WSP 14			252
WSP OUT OF RANGE 73 1207752 WSP 7			236
WSP OUT OF RANGE 73 1207751 WSP 12			238
WSP OUT OF RANGE 73 1207750 WSP 19			271
WSP OUT OF RANGE 73 1207749 WSP 0			
WSP OUT OF RANGE 73 1207748 WSP 24			247
WSP OUT OF RANGE 73 1207747 WSP 4			116
WSP OUT OF RANGE 73 1207746 WSP 4			141
WSP OUT OF RANGE 73 1207745 WSP 10			271
WSP OUT OF RANGE 73 1207744 WSP 4			144
WSP OUT OF RANGE 73 1207743 WSP 0			
WSP OUT OF RANGE 73 1207742 WSP 10			143
WSP OUT OF RANGE 73 1207741 WSP 16			214
WSP OUT OF RANGE 73 1207740 WSP 7			242
WSP OUT OF RANGE 73 1207739 WSP 10			211

Figure 10. Editing Output Illustrating the Chronological Listing of Mesonet Stations Whose One-Minute Averages of Temperature (TT), Dewpoint (TD), or Wind Speed (WS), lie Outside the Expected Range of Values

values of temperature, dewpoint, and wind speed that occur ten times or less in any of the frequency categories of the three variables. The purpose is to isolate and identify those observations that lie outside the normal range of observations (e.g., see Figure 7, the few outlying temperatures at stations 1, 2, 5, 8, and 25). Two of the variables, wind direction and extinction coefficient, do not lend themselves as readily to this technique. Their values may fluctuate over the full range of measurement during relatively short periods of time. Their erroneous observations, therefore, are not as easily indicated. Referring to Figure 10, the first line of the output shows that a wind speed (WS) of 21.2 knots occurred on January 20, 1973, 2240 GMT, at Station 15-CHS. Examination of the wind-speed frequency output, Figure 6, shows this to be a reasonable, though not frequently occurring, wind speed; therefore, it is not edited out. A quick examination of the wind-speed column (WS) shows that all the wind speeds reported are reasonable and acceptable.

Examination of the temperature column (TT) shows that Station 5-LAW reported a temperature of -1.1°F on January 20, 2348 GMT. Examination of the frequency distribution for this station in Figure 7 shows this value should be edited. Of the remaining three temperature values, two were observed by BSH, and that station temperature sensor data has already been completely eliminated (see discussion of Figure 7). The final temperature, which is out of range in this example, is the report by station 5-LAW of 11.8°F on January 21, 1973, 0026 GMT. Examination of the LAW frequency distribution in Figure 7 shows this may be an acceptable reading. Further examination of the individual hourly records of this station, however, revealed this value to be well outside the normal range of temperatures reported during that hour; therefore, it was deleted.

Finally, the dewpoint column shows that Station 3-PLM observed three widely varying values of 0.3 - 3.7 , and 3.9°F within a three-minute period. Such a variation is not reasonable and therefore it was edited out. The last dewpoint value of -6.5°F observed by Station 18-MTR on January 21, 0016 GMT, also provide, upon examination of Figure 8, to be well outside the expected range of values and, therefore, it was edited out.

5. CLIMATOLOGY OF THE MESONETWORK

The term climatology, as used here, denotes the study of meteorological variables with respect to their dependence on geographical location within a mesoscale-sized area. The variables specifically analyzed in this study are atmospheric extinction coefficient, wind speed, and wind direction. The geographical location is, of course, the Hanscom Air Force Base area and its surroundings.

5.1 Data Base

The unedited data base collected by the AFGL Mesonetwork during the four years of operation consisted of 420 magnetic tapes. In this initial effort, 111 of the tapes representing the one-year period from September 1972 through August 1973, have been edited. Data (temperature, dewpoint, visibility, wind direction, and speed) for all stations, were edited and stored on 16 master magnetic tapes in the form of one-minute averages. Editing of the remaining magnetic tapes will continue.

Major emphasis was placed on obtaining a data base to develop and test mesoscale probability forecast models and to serve in specification studies.

Thirteen of the stations were selected, based on geographical and topographical considerations, to illustrate the visibility and wind variations that occurred on the mesoscale during the first year of data collection. The climatological tables

(Volume II, Sections 2 through 6) have been constructed using the Air Weather Service ETAC Revised Uniform Weather Summary¹⁰ (RUSSWO) format as a model.

5.2 Hours of Operation

Table 2 shows the number of hours of operation, by month, during the first year of network operations for the wind and visibility sensors at each of the selected

Table 2. Hours of Operation of the Wind Sets and Forward-Scatter-Meters at Selected Stations in the AFGL Mesonetwork from September 1972 Through August 1973

STATION/SENSOR	1972				1973							
	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
3 WIND	416	449	0	273	313	416	477	614	706	674	603	445
PLM VSBY	446	466	295	536	426	497	516	633	707	674	605	445
7 WIND	77	461	226	560	476	466	472	667	668	514	605	440
NIP VSBY	451	461	533	601	476	548	486	667	668	669	605	449
8 WIND	452	389	401	550	281	290	487	646	711	685	427	453
BSH VSBY	447	394	479	653	328	371	489	658	711	685	632	453
9 WIND	433	462	273	496	475	527	457	657	708	685	633	453
SAG VSBY	0	446	536	664	475	546	520	658	708	685	633	453
10 WIND	0	81	536	629	480	538	520	506	704	681	632	453
TWK VSBY	449	90	510	664	480	537	520	506	704	681	597	453
13 WIND	452	465	219	581	349	453	520	667	712	682	664	449
HAC VSBY	318	465	536	664	349	466	520	667	712	682	664	449
15 WIND	452	465	509	627	452	525	520	667	712	684	665	449
CHS VSBY	447	465	535	664	452	528	520	667	712	684	560	449
20 WIND	335	464	536	535	407	440	520	667	712	682	664	448
RKO VSBY	446	187	536	664	408	501	520	667	712	682	666	448
21 WIND	95	0	96	526	480	548	445	250	633	692	672	453
NRY VSBY	327	81	536	667	480	548	520	667	712	692	666	452
22 WIND	260	458	438	629	475	532	520	667	148	0	0	0
WRY VSBY	449	466	536	666	475	532	520	667	702	0	160	0
23 WIND	260	465	533	667	480	544	520	667	640	625	666	441
ERY VSBY	350	465	534	667	480	544	520	667	638	626	652	451
26 WIND	0	0	0	0	0	26	486	534	669	667	431	431
TWL VSBY	0	0	0	0	0	0	480	579	669	667	605	449
28 WIND	0	0	0	0	134	467	520	667	707	677	605	451
TWH VSBY	393	461	533	575	432	548	520	667	707	677	605	451

stations. In the editing process, an hour of data was accepted if more than 30 minutes of observations were available during that hour. During the first few months of operation, some of the stations were not completely equipped with sensors. For example, the lower level of the tower (TWL) was not completely equipped until March 1973, and the upper level of the tower (TWH) was delayed until January 1973. Data retrieval problems reduced the number of observations from the WRY site during the latter part of 1973. As was expected, the winter months

10. Revised Uniform Summary of Surface Weather Observations (RUSSWO)
Part C and D, Station - Bedford, Massachusetts - Air Force Environmental Technical Application Center, Scott AFB, Illinois.

show a lower number of operations hours because of weather-related problems, and the difficulties in maintenance following instrument malfunction. The wind sets, in particular, experienced some freezing problems during the first winter of operation. This was essentially eliminated in the following years with the installation of heating cables around the base of each sensor during the summer of 1973.

5.3 Visibility Variation

As mentioned in an earlier section, visibility measurements in the Hanscom Mesonet were obtained using a forward-scatter-meter. This meter measures light scattered in a forward direction that is directly related to the atmospheric extinction coefficient (EXCO). The EXCO will be used in this and subsequent sections (Volume II, Sections 2 and 3) in lieu of visibility. EXCO values can easily be converted to day or night visibilities using Koschmieder's or Allard's Laws.¹¹

5.3.1 ANNUAL

Figure 11 is a cumulative frequency graph of EXCO of selected stations for the one-year period of the study (See Appendix B for monthly data for all thirteen stations). For reference, EXCO readings of $20 \times 10^{-4} \text{ m}^{-1}$, $40 \times 10^{-4} \text{ m}^{-1}$, and $80 \times 10^{-4} \text{ m}^{-1}$ represent daytime visibilities of about 1450, 725, and 369 meters, respectively.

The mesonet stations depicted on the graph are hill sites (BSH and SAG), coastal sites (PLM and NIP), a swamp site (HAC), a valley site (TWK), a 45 m elevation tower site (TWH), and a runway site (NRY). The final curve on the graph (BED) represents the values of EXCO frequency for Hanscom Air Force Base that were extracted from the visibility tables of the Hanscom RUSSWO¹¹ and converted using Koschmeider's equation. The graph clearly ranks the sites on the basis of location. The hill sites have the highest frequencies of occurrence, followed by the coastal sites. The tower site (TWH) ranks next and reinforces the significance of height above ground on frequencies of restrictive visibility. The remaining swamp, valley, and runway sites rank in that order but are of similar magnitude. None of these three sites could be categorized by a single descriptive term. Instead, each showed some of the characteristics of the others. Finally, it is interesting to note the similarity of the frequencies observed by NRY and by BED. On the one hand, the NRY curve represents one-minute average EXCO values over

11. Middleton, W. E. N. (1952) Vision through the Atmosphere, University of Toronto Press, Chapter 10, pp. 215-225.

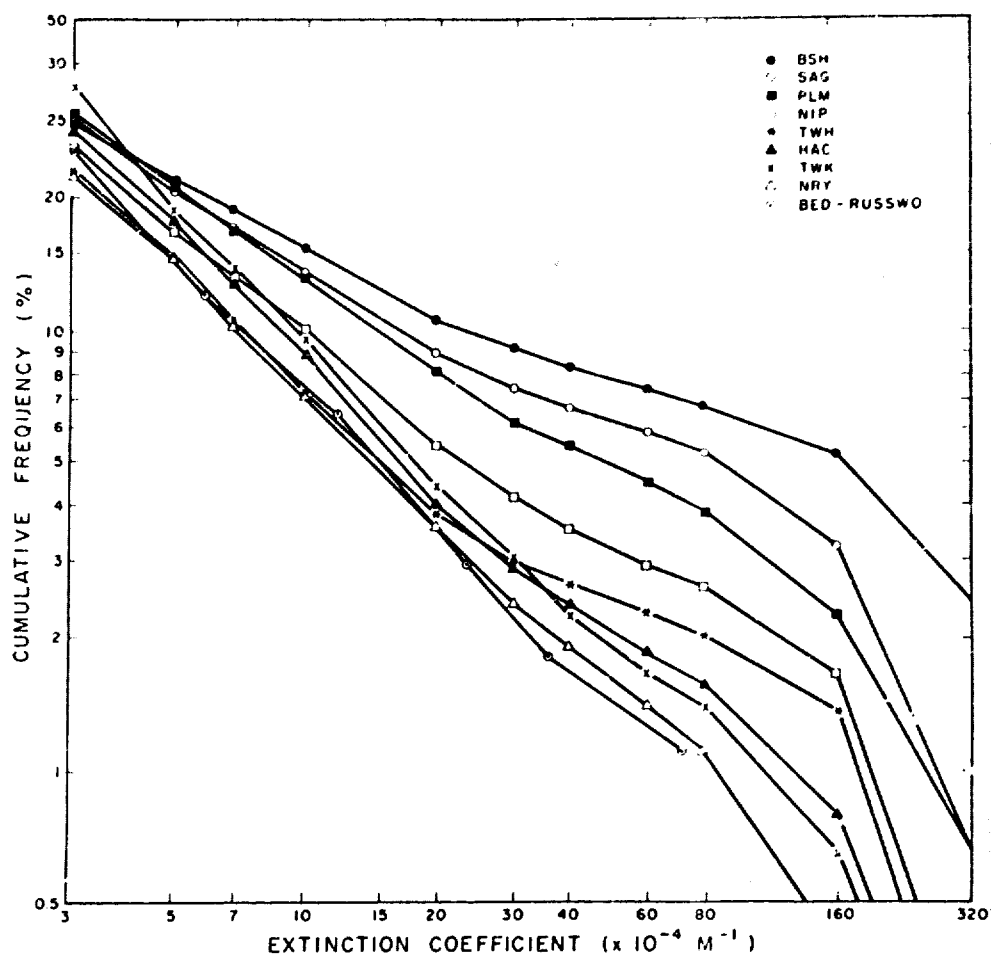


Figure 11. Cumulative Frequency Distribution of Extinction Coefficient at Eight Representative Stations in the AFGL Mesonet during the period September 1972 through August 1973.

the relatively short period of one year. On the other hand, the BED curve was based on one-hourly observations collected over a twenty-five-year period. It gives some assurance that the one-year data set was not significantly different from the long-term climatology, at least as represented by visibility.

5.3.2 DIURNAL

Figures 12 a-d show the diurnal percent frequency distribution of EXCO at four sites representative of the geographical/topographic variation within the mesonet. The curves illustrate the frequency of occurrence of EXCO observations that equaled or exceeded $20 \times 10^{-4} \text{ m}^{-1}$ (extracted from Volume II, Section 3). Four months (September, December, March, and June) were selected

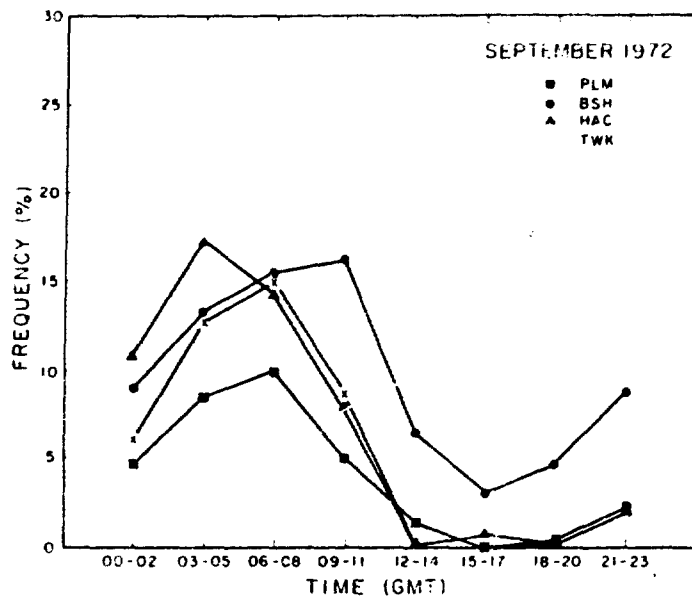


Figure 12a. Frequency Distribution of Extinction Coefficient Equal to or Greater Than $20 \times 10^{-4} \text{m}^{-1}$ Versus Time (GMT) of Day at Four Representative Sites for the Month of September 1972

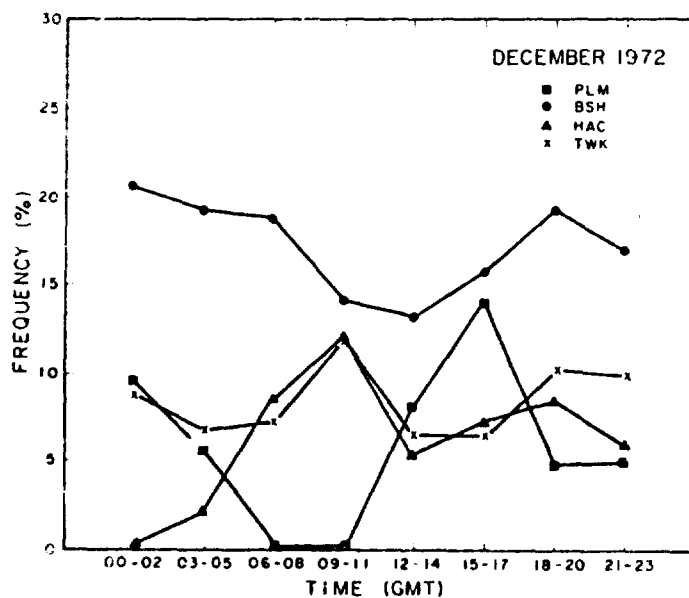


Figure 12b. Frequency Distribution of Extinction Coefficient Equal to or Greater Than $20 \times 10^{-4} \text{m}^{-1}$ Versus Time (GMT) of Day at Four Representative Sites for the Month of December 1972

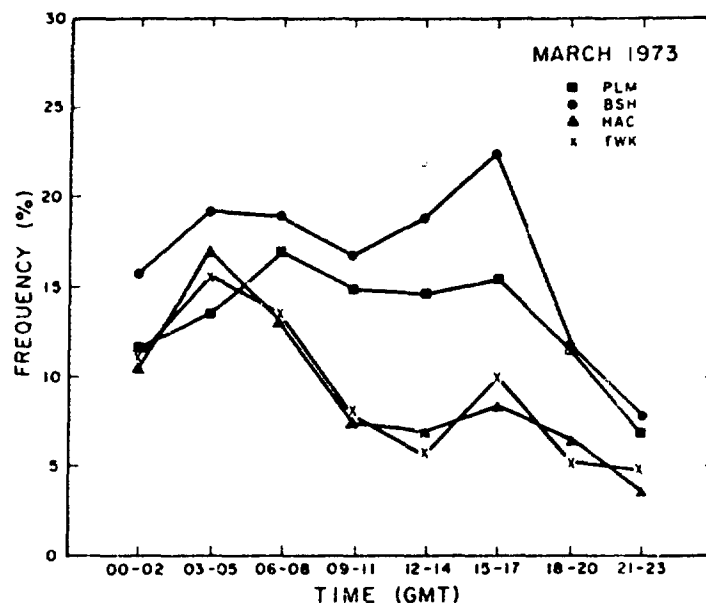


Figure 12c. Frequency Distribution of Extinction Coefficient Equal to or Greater Than $20 \times 10^{-4} \text{m}^{-1}$ Versus Time (GMT) of Day at Four Representative Sites for the Month of March 1973

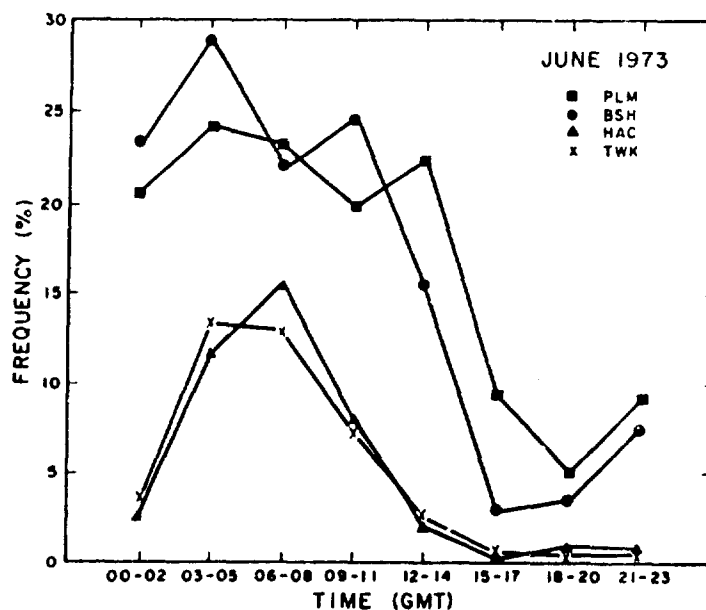


Figure 12d. Frequency Distribution of Extinction Coefficient Equal to or Greater Than $20 \times 10^{-4} \text{m}^{-1}$ Versus Time (GMT) of Day at Four Representative Sites for the Month of June 1973

to illustrate the seasonal variation. The percentages were computed with respect to a specific time category; example, 16 percent occurrence within the time period 0300 GMT to 0600 GMT, relative to the total observations occurring in that time interval only.

During the month of September 1972, Figure 12a, all stations show a pronounced diurnal variation of EXCO with a nocturnal maximum. The swamp and valley sites, HAC and TWK, show higher frequencies at night, which is attributable to the increased number of radiation fog occurrences during the fall. BSH, a hill site, has a higher overall frequency of lower visibility that reflects the effects of low clouds intercepting hilltops, especially closer to the coast, while PLM, a low coastal site, shows the moderating influence of the ocean on radiative log occurrence.

The winter month, Figure 12b, gives a chaotic appearance with no pronounced diurnal effects. The high frequency of occurrence throughout the day at BSH, the hill site, is probably due to the effect of traveling winter storms that produce low clouds and visibilities, irrespective of the time of day. The remaining stations have lower frequencies of high EXCOs and show no consistent diurnal pattern.

The spring month, Figure 12c, shows a gradual return to a diurnal variation of EXCO at the swamp and valley sites, HAC and TWK. The hill and coastal sites, BSH and PLM, on the other hand, continue to exhibit high frequencies of EXCO throughout the day.

During June 1973, Figure 12d, a pronounced diurnal variation was re-established at all sites. BSH and PLM, the hill and coastal sites, show very high frequencies of occurrence during the night. The inland and low sites also show pronounced nocturnal maxima, but of lower magnitude. These frequencies reflect the large number of coastal advective fogs that predominate along the New England coast during this period of the year, several of which can penetrate well inland.

5.4 Wind-Speed Variation

The wind sets at all stations, except for those located on Hanscom Air Force Base (ERY, WRY, and NRY), were mounted on telephone-type poles at a height of 8 m above ground level. The Hanscom instruments, because of runway safety restrictions, were limited to a height of 4 m. Wind speed is specified in knots in this section and in Volume II, Sections 4, 5, and 6.

5.4.1 ANNUAL

Figure 13 is a cumulative frequency distribution of wind speed at selected stations in the mesonetwork, for the twelve-month data period. Stations were

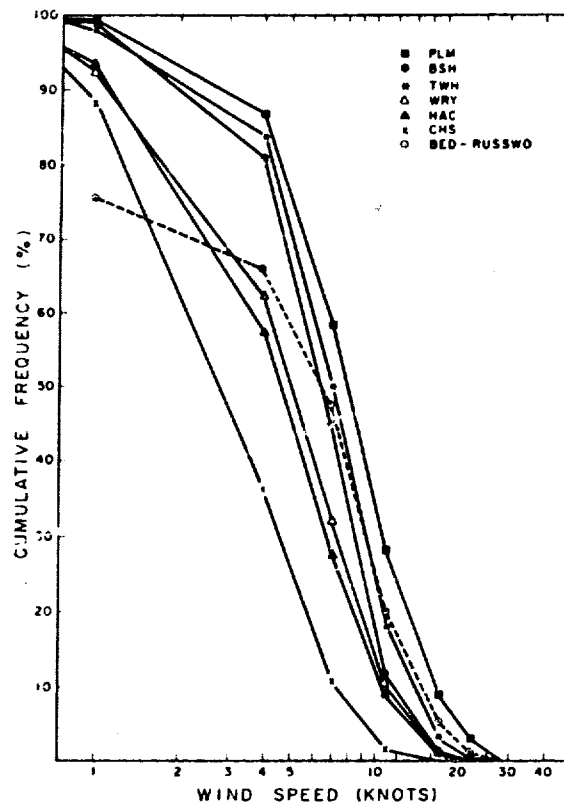


Figure 13. Cumulative Frequency Distribution of Wind Speed at Six Representative Station in the AFGL Mesonetwork During the Period September 1972 through August 1973

selected to represent characteristics of hill tops (BSH), coasts (PLM), swamps (HAC), valleys (CHS), runways (ERY) and towers (TWH). In addition, the RUSSWO¹¹ data were used to extract the cumulative frequency curve for Hanscom Air Force Base (BED).

The station with the greatest frequency of wind speeds equal to or greater than 11 knots is PLM, a coastal site. Next in rank are two stations where height plays the major role, TWH (45 m level on tower) and BSH (hilltop site). The remaining stations, in descending order, are the ERY (a runway site, similar to a valley), HAC (a swamp site with relatively open exposure), and CHS (a valley site with significant surrounding topographical features).

The BED curve is of considerable interest because, at the higher speeds, it more nearly resembles the tower curve at Bedford (TWH) than the surface runway site (ERY). There could be several explanations to account for this; example, the operational and mesonetwork wind sets were different and, in fact, the high start speed of the operational wind sets accounts for the sharp drop in wind-speed

frequency below four knots. In addition, we are comparing a long-term climatology (BED) with a one-year sample (TWH and ERY). At the same time, we are comparing statistics generated by the one-minute, minute-to-minute wind-speed averages of the mesonetwork (ERY, TWH) with one-minute wind speed recorded on an hourly-observation cycle at BED. Examination of the RUSSWO also indicates that the wind observations for a nine-year period of time at BED were taken from a set mounted on the top of a hangar (70 ft) or the weather station building (37 ft). Prior to that, the location of the wind set was not specified for a ten-year period. Thus, the BED frequency curve more nearly exhibits the characteristics of a sensor mounted at a substantial height above the ground.

5.4.2 DIURNAL VARIATION

Figures 14A-D were constructed to examine the diurnal variation of wind speed during each season at mesonetwork stations selected to represent coastal, hilltop, valley, and swampy locations. Frequencies for all wind speed equal to or greater than 11 knots were extracted from Volume II, Section 5.

A pronounced diurnal variation of speed occurred at all stations in each season. PLM, the coastal site, had the highest frequencies of winds over 11 knots for all four seasons. The greatest frequency of high winds occurred during March at the hill (BSH), swamp (HAC), and valley (CHS) sites. The greatest frequency of high winds at the coastal site (PLM), however, occurred during December. This figure reaffirms the results seen in Figure 13, that the coastal, hill, swamp, and valley sites rank in that order of high wind-speed frequency.

5.4.3 TOPOGRAPHIC EFFECTS ON HANSCOM AIR FORCE BASE WIND SPEED

Measurements of surface wind speed and direction were made at three locations at Hanscom Air Force Base, Figure 1. The topography of each site, seen in Appendix A, denotes significant topographical features that surround the field. The WRY site is located just to the east of Pine Hill, which rises 33 m above the runway level. Although not shown on the topographical chart, the NRY site was located to the southwest of a densely wooded area. Consequently, winds from the northeast could be affected. In addition, hills are located to the northwest and southeast of the station. The ERY site, on the other hand, was situated just north of a major obstruction, Kahtahlin Hill. To the east and northeast of the ERY site are dense forests, with another hill further to the east northeast.

To validate the effects of the topographic features on the runway winds, the bivariate percentage frequency distributions, listed in Volume II, Section 6, were examined for the three sites. Figure 15 depicts the distribution for April 1973, a month that shows the topographic effect most clearly because of the high frequency

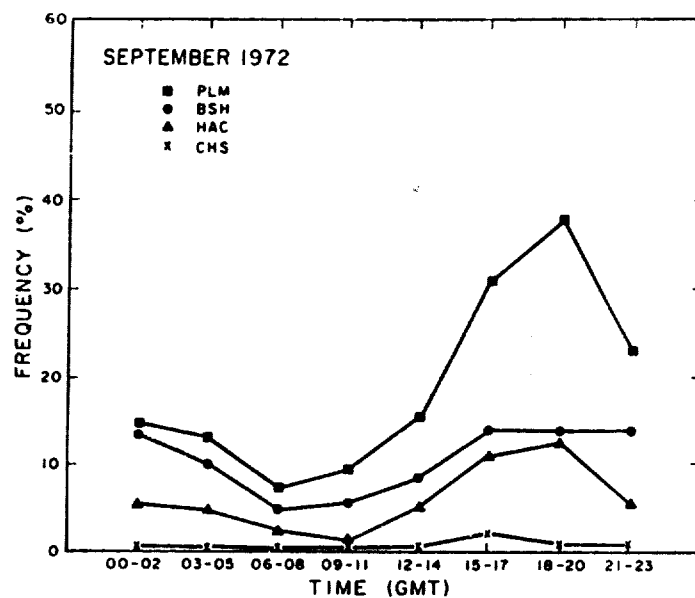


Figure 14a. Frequency Distribution of Wind Speed Equal to or Greater than 11 Knots Versus Time of Day at Four Representative Sites for the Month of September 1972

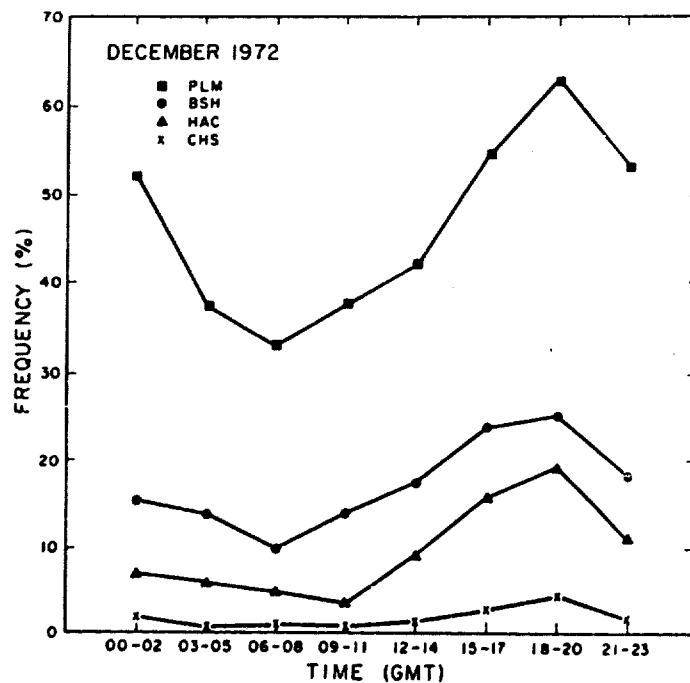


Figure 14b. Frequency Distribution of Wind Speed Equal to or Greater than 11 Knots Versus Time of Day at Four Representative Sites for the Month of December 1972

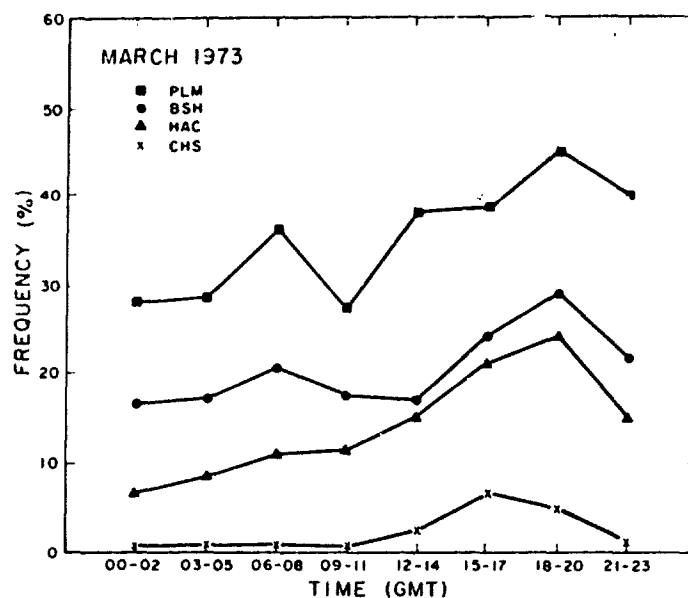


Figure 14c. Frequency Distribution of Wind Speed Equal to or Greater than 11 Knots Versus Time of Day at Four Representative Sites for the Month of March 1973

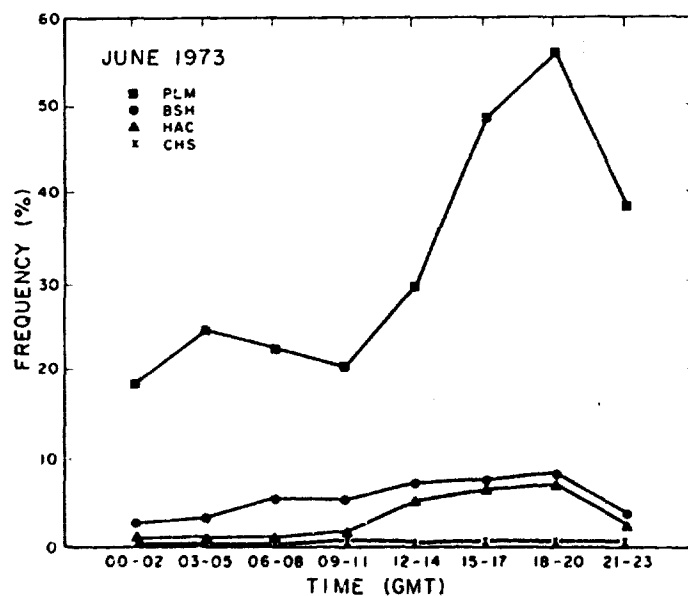


Figure 14d. Frequency Distribution of Wind Speed Equal to or Greater than 11 Knots Versus Time of Day at Four Representative Sites for the Month of June 1973

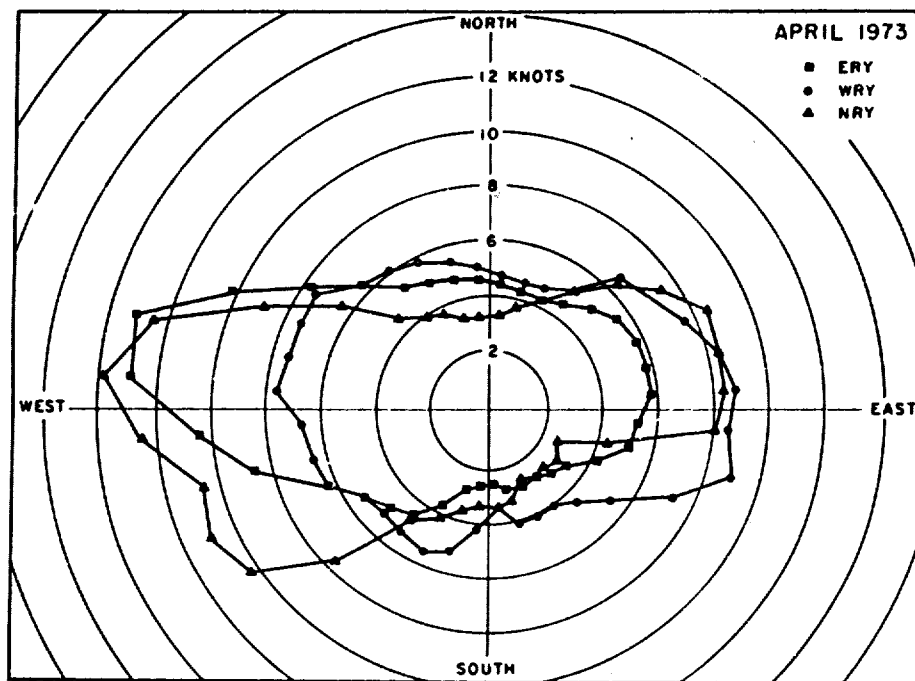


Figure 15. Distribution of Average Wind Speed as a Function of 10-Degree Direction Intervals During the Month of April 1973 for Three Stations Located Along the Principal Runway at Hanscom Air Force Base, Massachusetts

of strong east and west winds during the month. For west-wind occurrences, the NRY and ERY have a long unobstructed fetch across the airfield, and appreciably stronger winds were observed than at the WRY, located in the shadow of Pine Hill. Conversely, for easterly winds, the WRY and NRY reported stronger winds than the ERY, because they experience unobstructed flow during east winds. Consistent with other topographic features, the ERY reports lower southerly wind speeds than the other two stations, and the NRY reports lower wind speeds from the north than the ERY and WRY.

6. SUMMARY

The results of the climatological survey can be summarized as follows:

- (i) An editing program for the AFGL Mesonet network has been written, tested, and utilized in editing 12 months (111 tapes) of data between September 1972 and August 1973. The edited data (temperature, dewpoint, wind direction and speed, and visibility) for the twenty-six station network have been compacted and stored on sixteen magnetic tapes in the form of one-minute averages.

(ii) Edited hard-copy output for each of the 111 tapes has been generated in the form of one-hour averages of the variables (Figure 3); daily averages (Figure 4); and frequency distributions of wind direction (Figure 5), wind speed (Figure 6), temperature (Figure 7), dewpoint (Figure 8), and visibility (Figure 9).

(iii) Topographic charts were constructed for each of the mesonetwork stations to show the location of features that could have a significant local effect on the data.

(iv) A twelve-month climatological survey was conducted with thirteen of the stations of the mesonetwork. Selection was based on topographic features or geographic location in the network. The representation included two tower sites (TWL and TWH); three runway sites (NRY, ERY, WRY); two swamp sites (HAC and RKO); two valley sites (CHS and TWK); two hill sites (BSH and SAG); and, finally, two coastal sites (NIP and PLM). The survey was limited to extinction coefficient (visibility) and wind direction and wind speed.

(v) Cumulative frequency curves for the twelve-month study ranked the stations according to frequency of visibility restrictions. The highest frequencies were observed by the hill sites, and decreased in frequency to the coastal sites, the runway sites, and to the lowest frequencies at the valley sites. Comparison of the Hanscom Air Force Base mesonet data (NRY) with the Hanscom Air Force Base RUSSWO data (BED) indicated the twelve-month period was close to the long-term climatology for visibilities.

(vi) Diurnal variation of extinction coefficient throughout four months representative of the four seasons were graphed. They showed strong diurnal variation with nocturnal maxima in fall and summer, and no pronounced diurnal effect in winter and spring. The effects of coastal fog in June on the network was quite apparent.

(vii) Frequency curves of wind speed for selected stations for the twelve-month period clearly specified the coastal and hill sites as having the highest frequencies of high winds. Due mainly to sheltering effects of surrounding topography, the valley site showed the lowest frequencies.

(viii) Diurnal variations of wind speeds were graphed for four months representative of the seasons. Strong diurnal variation was apparent for all seasons.

(ix) A comparison of three stations located along the runway at Hanscom Air Force Base, during the month of April 1973, revealed the effects of surrounding topography on the surface wind speeds. Significant shadowing of wind speeds occurred on the lee sides of hills and forests.

This initial mesoclimatology analysis considered three variables at thirteen stations for a period of one year (September 1972 through August 1973). Extension to the remaining stations, variables, and years two, three, and four of the

full sample is continuing. In the meantime, the edited one-year data base is being used in the development of short-range forecasting techniques, and in time and space variability and specification studies.

Appendix A

Topographic Charts

Topographical charts for each mesonetwork station have been prepared together with descriptive comments on each station. Each chart covers an area of 1.8 km x 1.8 km and contours are drawn for every 20 ft. While the analysis described in this report was limited to 13 of the stations, edited and processed data for all 31 locations listed in this Appendix are available on magnetic tape for further study.

1. HMP - 2 m

The site at Hampton, New Hampshire was the lowest in elevation of any site in the network. The sensors were located within 5 m of the edge of the tidal flats that separated the mainland from the barrier island further to the east. Exposure to the east and south was excellent. Some trees were located to the north and west.

1A. DEV - 79 m

This site was situated at Ft. Devens, Massachusetts on a small plateau that was open, quite flat, and relatively free of trees. To the east, a rather abrupt drop in height occurs to a valley that contains the Nashua River.

2. AMS - 87 m

The site at Haverhill, Massachusetts was just below the crest of Powwow Hill (101 m) and located on its southeast face. This side of the hill had been cleared of trees, and the exposure to the north, east, and south was excellent. Nearby water bodies are Lake Gardner to the west, and the Merrimack River, 2.5 km to the south.

2A. MIL - 84 m

This site was located just north of the Town of Milford, Massachusetts on a relatively flat stretch of land between a range of hills to the east, and Cedar Swamp Pond to the west. The surrounding area was being utilized as a sanitary land fill, and was free of obstructions in all directions. Drainage was from north to south 90°. The remaining three quadrants consisted of open clear fields out to 1 km, and are slightly lower in elevation (40 m) than the tower site. Pine Hill (70 m in height) is located about 1.3 km to the southwest.

3. PLM - 3 m

The site at Plum Island was situated at the northern extremity of the island in an area of sand dunes. Exposure in all directions was excellent. Very little vegetation existed in the area, and topographic features were minor. The northern and western boundaries are the Merrimack River, while the eastern boundary is the Atlantic Ocean.

3A. PLM - 2 m

The original site at Plum Island (3) was relocated when the Coast Guard moved to new quarters. The new mesonetwork location at the Plum Island Airport was 3 km southwest of the first site. Exposure was excellent in all directions.

4. HAV - 49 m

The Haverhill station was located in a region of complex topographic features. Three lakes, Pentucket to the northwest, Saltonstall to the south, and Kenoza to the east, surround the site. Contrasting with the lakes are hills to the north, southeast, and south-southwest. Drainage flow in the vicinity of the site was toward the northeast.

5. LAW - 50 m

The Lawrence site was located at Lawrence Municipal Airport. A small stand of trees was located southwest of the site on a small hill. Exposure of the instruments was very good. The principal topographic features in the vicinity are Osgood Hill (105 m), located 1.2 km to the southeast, and Lake Cochichewick, located just off the end of the southeast runway.

6. GEO - 23 m

The Georgetown site was located on private land just west (60 m) of Interstate Highway 95. The site was on a minor ridge line that extended southwest-northeast. Surface drainage was toward the northeast. The closest trees were about 300 m distant.

7. NIP - 17 m

The North Ipswich, Massachusetts site was located on land leased by AFGL and used as a radio astronomy site. The site was on a slight rise of land that was surrounded by saltwater marshes. The only significant feature within a mile of the site was a band of trees oriented east-west along the 20-ft contour to the north of the station.

8. BSH - 114 m

Boston Hill, located in North Andover, Massachusetts was one of the principal hilltop sites in the mesonet network. It was also one of the most completely instrumented sites with temperature, dewpoint, forward-scatter-meter, rain gauge, wind direction and speed, and transmissometer. The top of the hill had been cleared and was being used by Mitre Corporation as an instrument facility. The major obstruction on the hill was a six-story concrete building, formerly used as a radar site. This building was located 76 m south of the mesonet site. Drainage at the site was downslope to the north.

9. SAG - 56 m

This station was located on the easternmost peak of Sagamore Hill. Located in the same vicinity was the 18-m solar telescope operated by AFGL. This was located just to the west of the mesonet station site. The top of the hill had been

cleared of trees; however, the lower elevation was still densely forested. This site, along with BSH (Boston Hill), was one of our four major hilltop locations. The surrounding hills, Eveleth to the south, Willow to the north-northeast, and Sagamore to the west, reach heights of 59, 54, and 57 m, respectively.

10. TWK - 35 m

This station was located on open flat terrain just northeast of a hill that was approximately 53 m in height. Situated directly to the east at about 300 m was a grove of oak and pine trees that were about 10 m in height. A complex of brooks combined just to the northwest, proceeds east, and then joins Meadow Brook and drains south. Surface drainage flow in the immediate vicinity of the site was toward the southeast.

11. MID - 64 m

The station was located on the northeast slope of a hill that extends to 70 m in height. The area surrounding the site had been cleared and converted to use as farms. Buildings of the Essex County Industrial Farm were also located in the vicinity of the site. Drainage in the immediate location was to the northeast and northwest.

12. AVC - 47 m

This station was located on the southwest side of a hill that extends to 52 m in height. The vegetation had been cleared from the hilltop for the installation of a tower facility by AVCO, Inc. Trees still surrounded the base of the hill in a narrow band, and the area southwest of the site was characterized by low marshy land. Drainage in the vicinity of the site was toward the southwest.

12A. SUD - 64 m

This site was located at the U.S. Military Reservation, Natick Laboratory. It was situated on relatively flat land, between three hills, and was bounded on the north by the Assabet River. Flow along the river was from the southwest to the northeast.

13. HAC - 23 m

This station was located on the southern edge of a marshy plain that bounds the Ipswich River. The site was owned by the Town of Reading and was being used as a water-pumping location. Higher ground lay to the east and southwest of the site, while to the north the land was lower in elevation. Drainage was from the south and west toward the northeast.

14. BIL - 32 m

This station was situated in a cleared area on the grounds of the Shawsheen Regional Technical School. Forests surrounded the cleared area. Drainage in the region was accomplished by the Shawsheen River to the west, and Lubbers Brook to the east. In general, flow was to the north. The only significant hill is to the northeast, which extends to 58 m in height.

15. CHS - 27 m

This station was located about 15 m east of Chestnut Street, on land used by the Town of Wilmington, Massachusetts for water resources. The area surrounding the site was clear of trees to about 300 m. The site itself was situated on the northeast side of a hill which extends in height to 67 m. Drainage within a radius of 1 km was, generally, to the northeast, with the brooks eventually draining into the Ipswich River.

16. CCG - 30 m

This station was located on the grounds of Camp Curtis Guild, a Massachusetts National Guard facility. The land surrounding the site was flat and forested, while the Camp itself was cleared land. The weather site was located at the center of a large open field that was surrounded by small buildings. The site was also situated on the southern end of Center Swamps, about 600 m north of Lake Quannapowitt (elevation 25 m). Drainage was generally toward the east. No significant hills were located within a 1-km radius.

17. VHL - 38 m

This site was located on the grounds of the VA Hospital in Bedford, Massachusetts. The site was characterized by higher ground to the east and west. The valley slopes downward from the north to the south-southeast, and a small spring drains into the Shawsheen River. Wooded areas exist to the northwest, north, and east. The area to the west and southwest was unobstructed. The VA buildings were located about .8 km west of the site.

18. MTR - 38 m

This station was located on a flat open field between Burlington Road (Route 62) and the Mitre Corporation in Bedford, Massachusetts. The station was 40 m north of the road. Higher ground lies to the north and south. The valley is oriented nearly east-west, with drainage to the west. A large complex of buildings (MITRE) was located about 450 m to the north. Several buildings were located on the other side of Burlington Road.

18A. SIIR - 165 m

This site was located at the Hill Street Pumping Station in Shrewsbury, Massachusetts. It was located in a valley that was drained by Rawson Hill Brook from west to east. The site was free of trees and was open in all directions.

19. NKE - 49 m

This station was located 3 km northwest of Hanscom AFB at a deactivated NIKE site. The site was a small hill (51 m) surrounded by low (36 m) marshy land that comprises part of the Great Meadows, which bound the Concord River. The river itself lies 1.5 km to the west of the site.

20. RKO - 40 m

This site was located on the southern edge of a swampy drainage area at the site of the Burlington Meadow Street Pumping Station. The northwest and northeast quadrants opened into a large open meadow with low ground and standing water. The southeast and southwest quadrants are predominantly high ground, separated by a drainage brook, which flows from south to north into the meadow.

21. NRY - 38 m

This station was located 245 m north of the central portion of the east-west runway at Hanscom AFB. The northeast quadrant consists of a level wooded area, beginning about 100 m northeast of the site, which slopes gently downward (about 3 m) into a marshy area. The southeast and southwest quadrants were open flat fields containing the runways, and were unobstructed for at least 1 km in all directions. The northwest quadrant contains Hartwell's Hill, located about .8 km from the site, which extends to a height just over 60 m.

22. WRY - 38 m

This station was located within 245 m of the west end of the east-west runway at Hanscom AFB. The northeast and southeast quadrants, extending to 1 km, were open flat fields comprising the remainder of the runways. The main physical feature in the western quadrants was Pine Hill, at a distance of 600 m, which rises about 33 m above the station.

23. ERY - 38 m

This site was located 245 m south of the east end of the east-west runway. The northeast quadrant was characterized by lower land with swampy conditions. Drainage was to the northeast, and formed the headwaters of the Shawsheen River. The southeast and southwest quadrants were dominated by the northern portion of Kahtahdin Hill. The land begins to rise about 200 m south of ERY, and reaches

a height of 226 m within 600 m. The northwest quadrant was open flat land, and contained the air-base runways.

21. DMP - 41 m

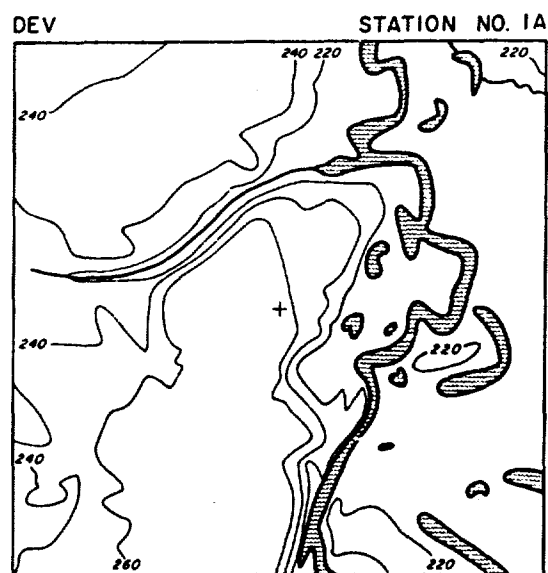
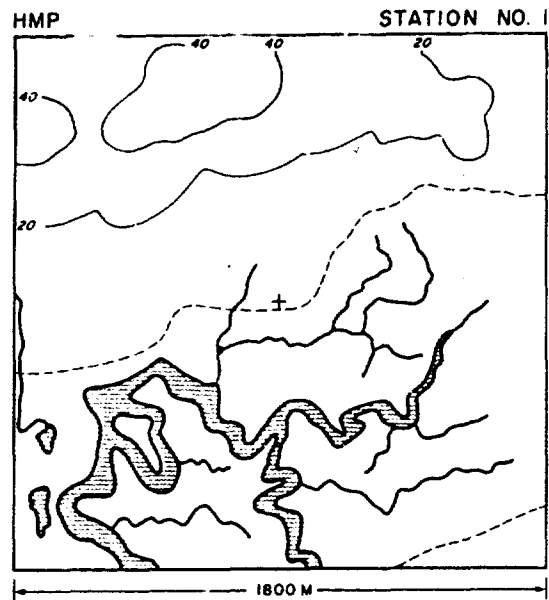
This station was located 670 m from the end of the southwest-northeast runway. The northeast quadrant contained a ridge line extending from northwest to southeast into higher ground (67 m) located in the southeast quadrant. The southwest and northwest quadrants contained land, lower than the site, which was, in general, quite marshy.

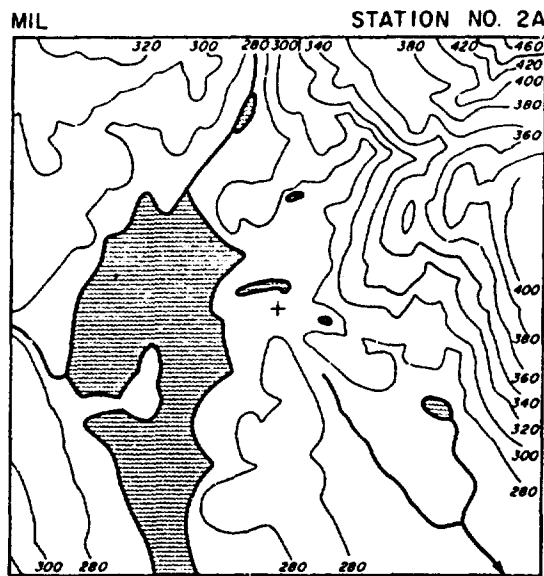
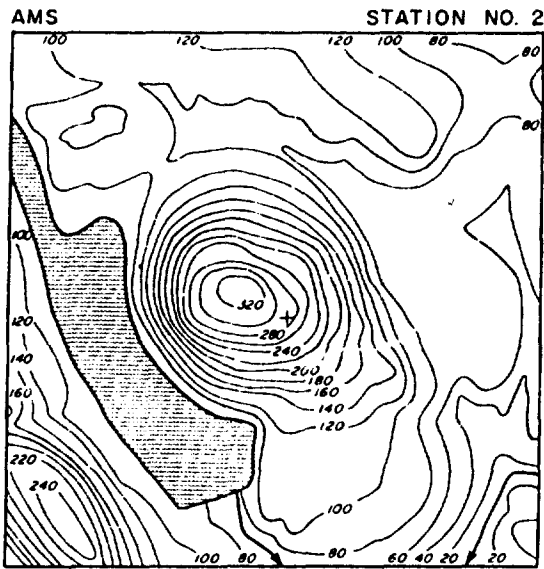
25. DPW - 53 m

This station was located in the southern portion of land used by the Commonwealth of Massachusetts DPW for highway maintenance. It was situated at the intersection of Route 2 and 128. The areas extending 1 km to the northeast and southeast are characterized by the residential areas of Lexington, Massachusetts. The station was surrounded by hills to the north, west, and southwest. Fiske Hill to the north, and Cranberry Hill to the west and southwest, rise to 91 m in height. Drainage was to the south, and the Cambridge Reservoir begins within .8 km.

26./28. TWL/TWH - 43 m

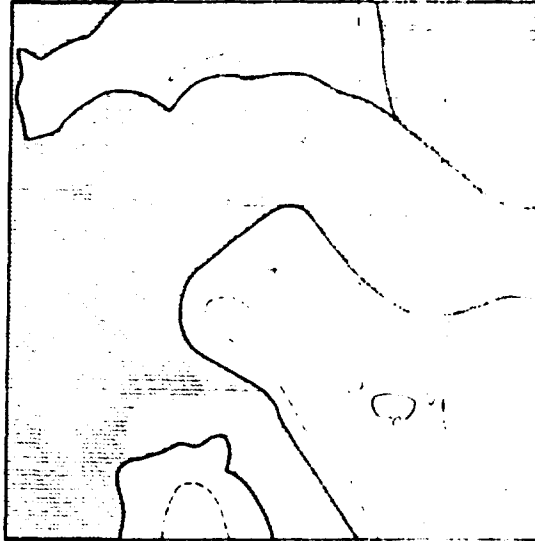
The tower site was located 550 m north of the center line of the east-west runway and about 800 m north-northeast of the WRY site. The major topographical feature affecting the tower was Hartwell's Hill (60 m in height) located about 500 m to the northeast, and subtending an angle from 20° to 90°. The remaining three quadrants consisted of open clear fields out to 1 km, and were slightly lower in elevation (40 m) than the tower site. Pine Hill (70 m in height) was located about 1.3 km to the southwest.





PLM

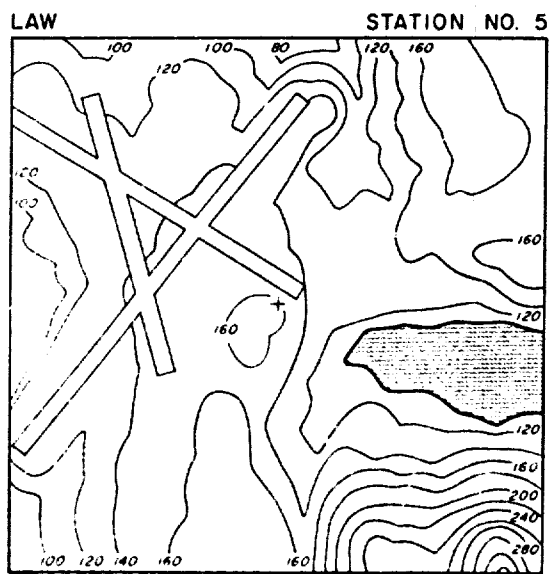
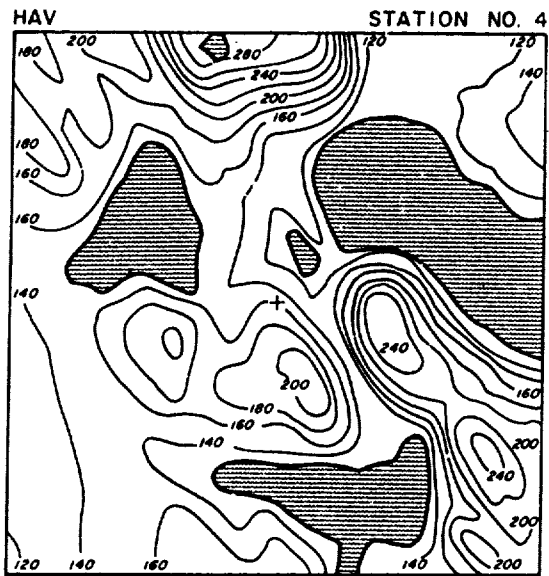
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PLM

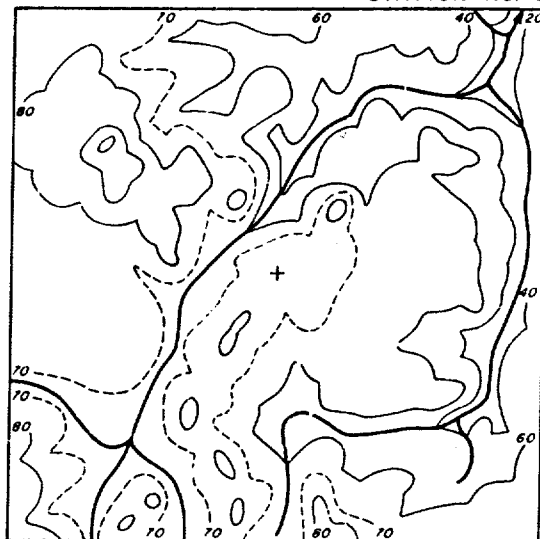
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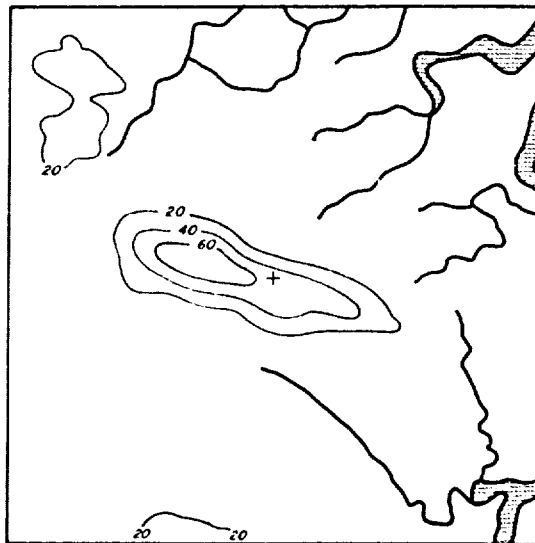
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STATION NO. 6



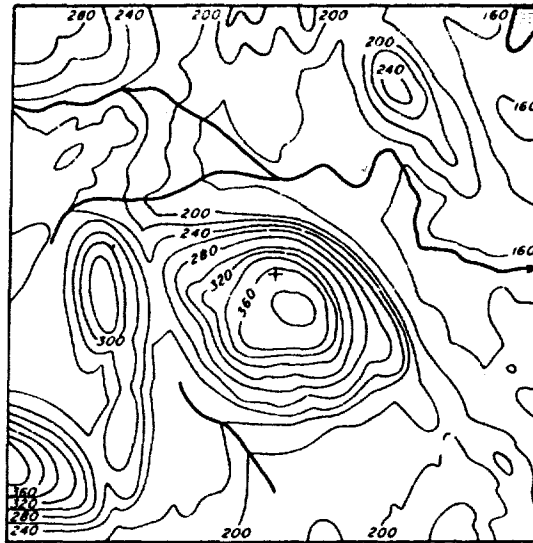
NIP

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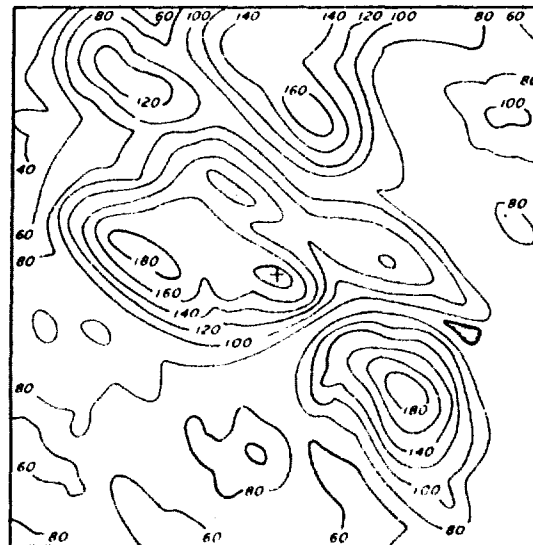
BSH

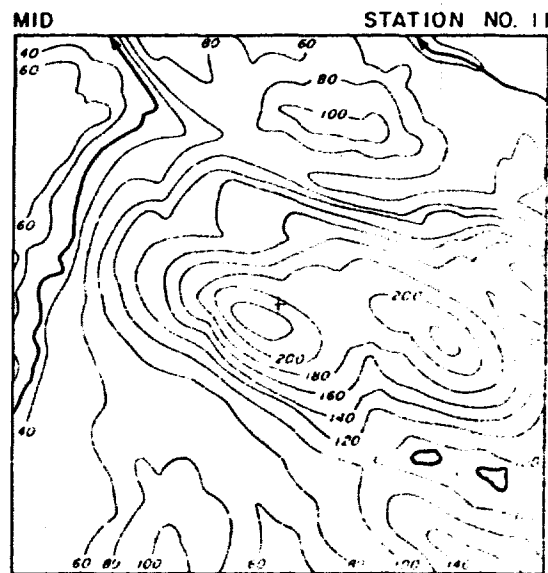
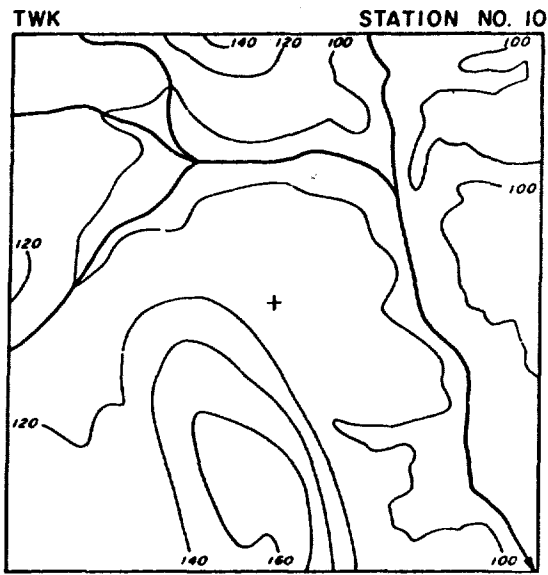
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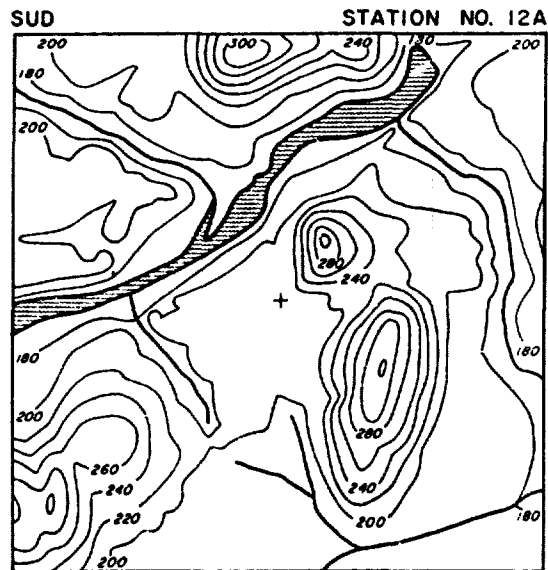
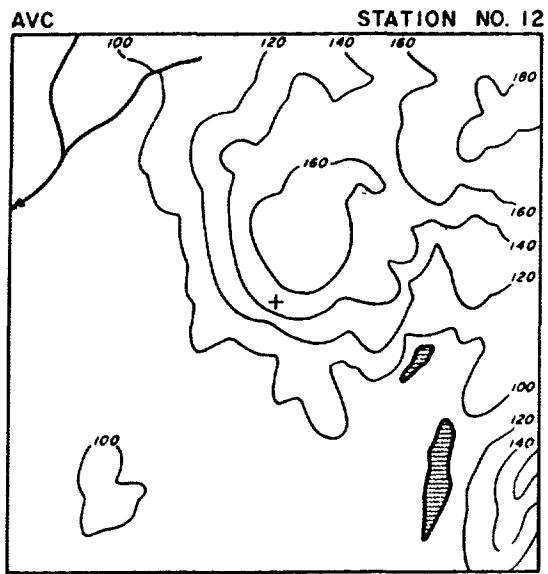


SAG

STATION NO. 9

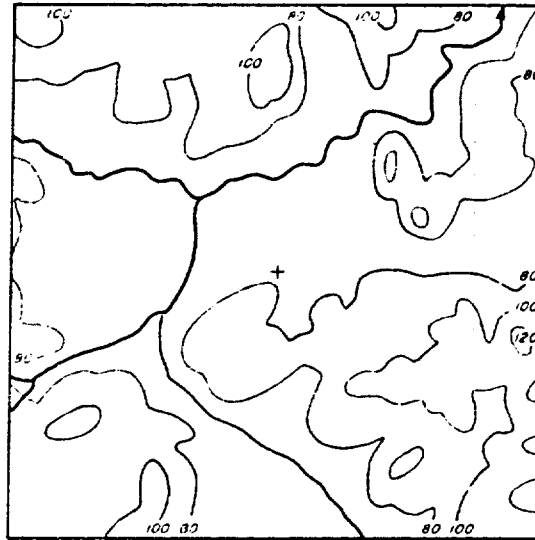






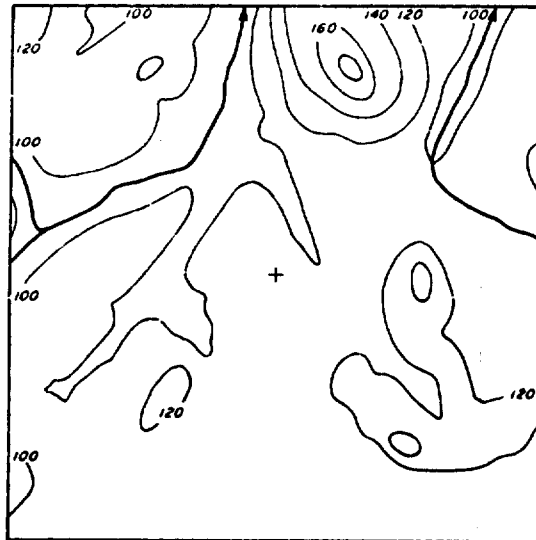
HAC

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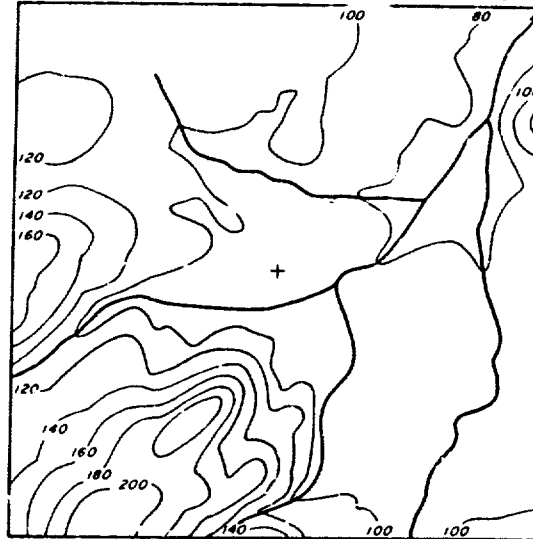
BIL

STATION NO. 14



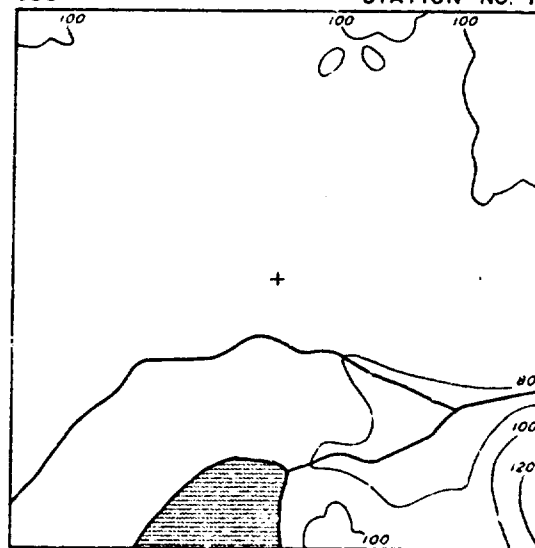
CHS

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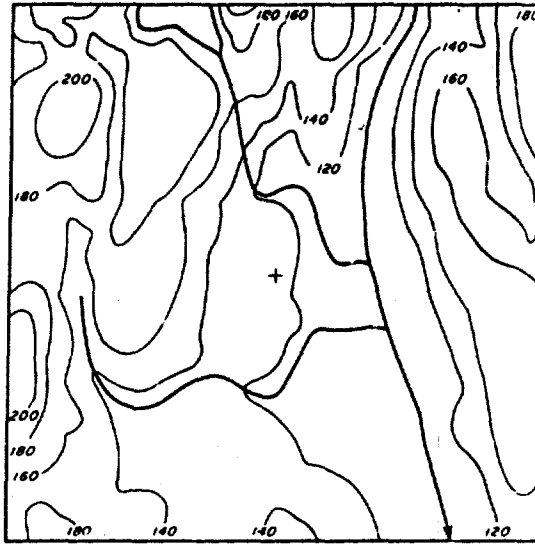
CCG

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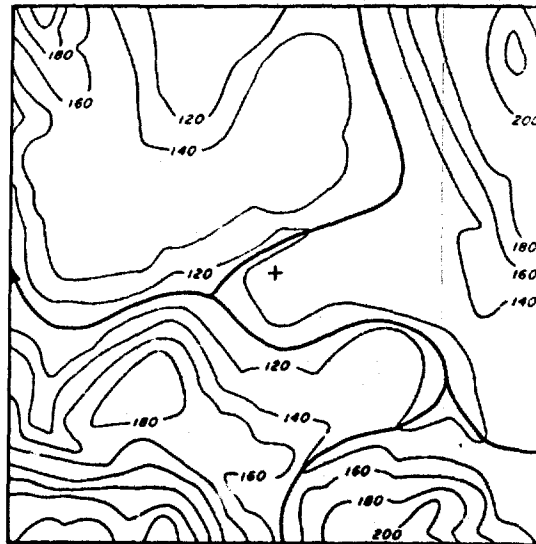
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STATION NO. 17



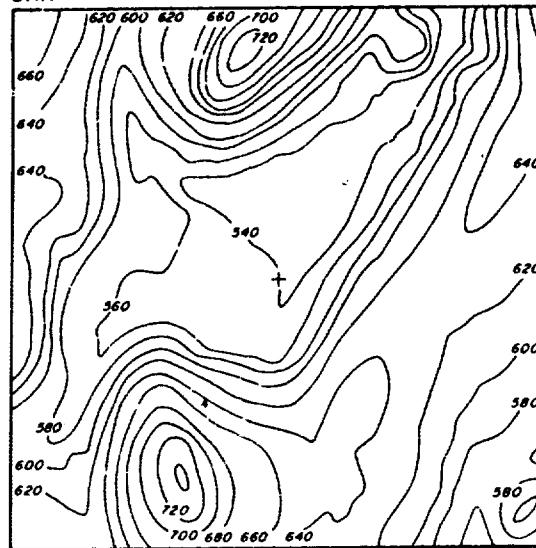
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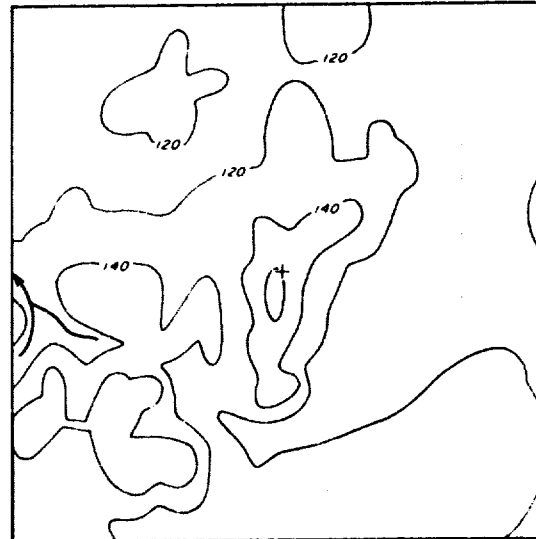
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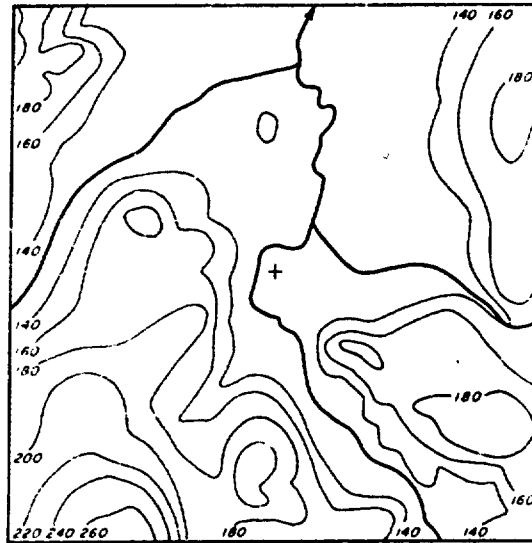
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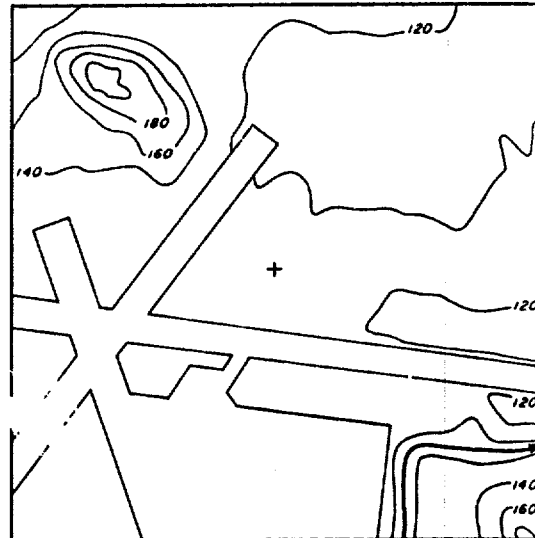
RKO

STATION NO. 20



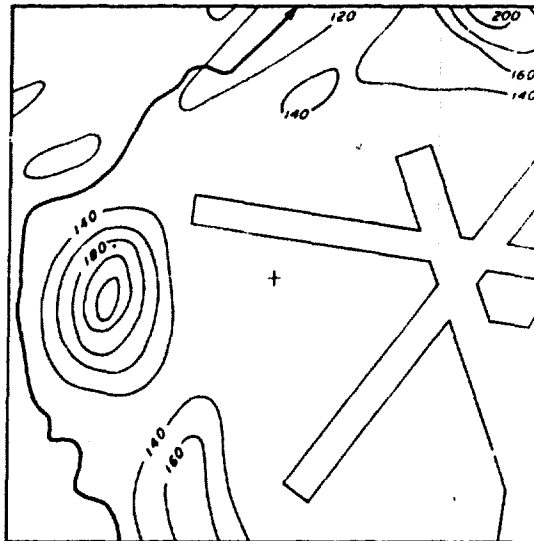
NRY

STATION NO. 21



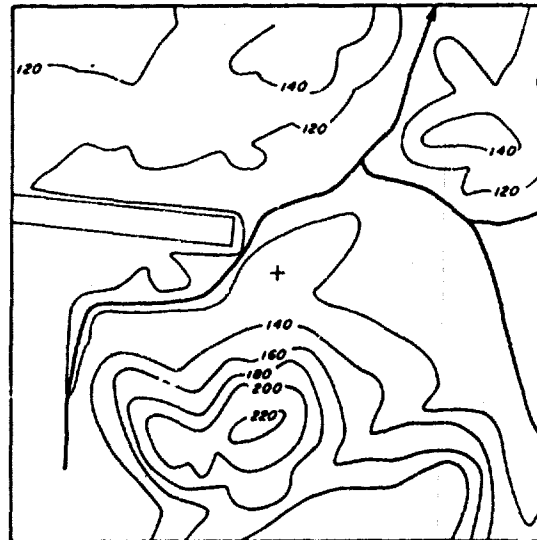
WRY

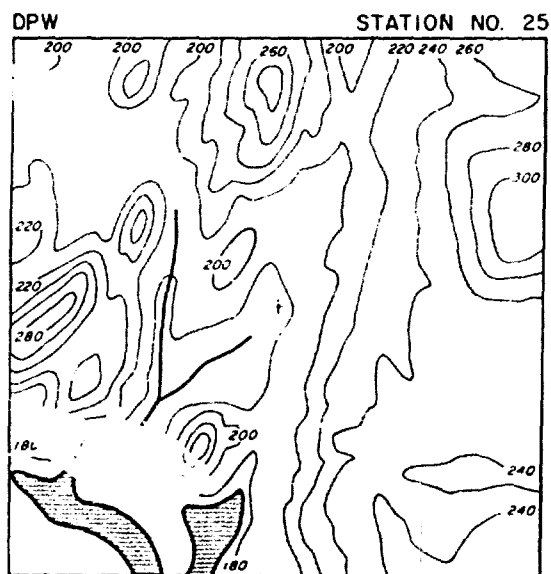
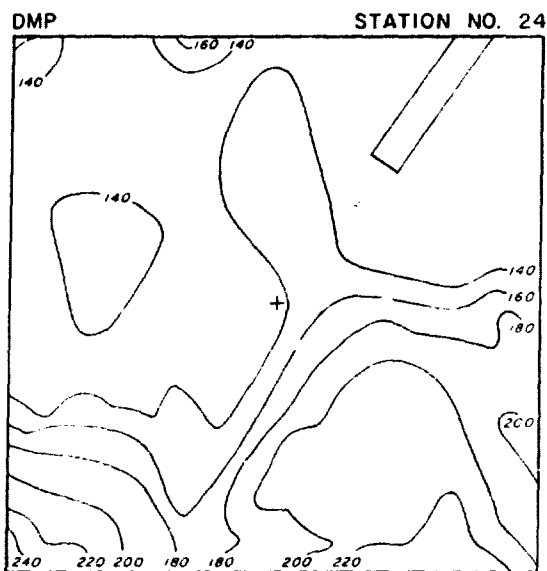
STATION NO. 22



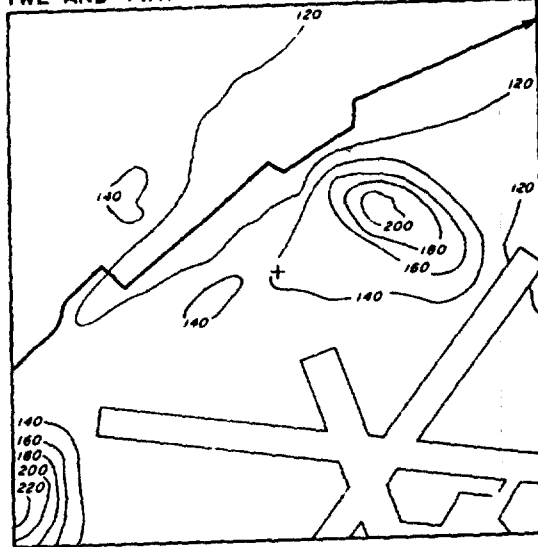
ERY

STATION NO. 23





TWL AND TWH STATION NO. 26 AND 28



References

1. Hering, W. S., Brown, H. A. and Muench, H. S. (1972) Mesoscale Forecasting Experiment, Bull. Am. Meteor. Soc., 53, 12:1180-1183.
2. Hering, W. S. and Quick, D. L. (1974) Hanscom visibility forecasting experiments, Proc. 5th Conf. on Weather Forecasting and Analysis, pp. 224-227.
3. Chisholm, D. A. and Kruse, H. (1974) The Variability of Visibility in the Hanscom Mesonetwork: A Preliminary Assessment, AFCRL-TR-74-0265 AD784791.
4. Tahnk, W. R. (1975) Objective Prediction of Fine Scale Variations in Radiation Fog Intensity, AFCRL-TR-75-0269, ADA014774.
5. Chisholm, D. A. (1976) Objective Prediction of Mesoscale Variations of Sensor Equivalent Visibility During Advective Situations, AFGL-TR-76-0132, ADA030332.
6. Hering, W. S., Muench, H. S., and Brown, H. A. (1971) Field Test of a Forward Scatter Visibility Meter, AFCRL-71-0315, AD726995.
7. Muench, H. A., Moroz, E. Y. and Jacobs, L. P. (1974) Development and Calibration of the Forward Scatter Visibility Meter, AFCRL-TR-74-0145, AD783270.
8. Chisholm, D. A. and Jacobs, L. P. (1978) An Evaluation of Scattering-Type Visibility Instruments, AFCRL-TR-75-0411, ADB010224L.
9. Brown, H. A. (1979) Preliminary Assessment of an Automated System for Detecting Present Weather, AFGL-TR-79-0137, ADA078031.
10. Revised Uniform Summary of Surface Weather Observations (RUSSWO) Part C and D, Station - Bedford, Massachusetts - Air Force Environmental Technical Application Center, Scott AFB, Illinois.
11. Middleton, W. E. N. (1952) Vision through the Atmosphere, University of Toronto Press, Chapter 10, pp. 215-225.