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STATISTICAL DATA FROM NASA'S 150-m WIND TOWER AT KENNEDY SPACE CENTER, FLORIDA

By Kelly Hill
Aero-Astrodynamics Laboratory

July 30, 1971

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A statistical summary of ground wind data for the Kennedy Space Center, Florida, recorded at NASA's 150-m Ground Wind Tower on Merritt Island is presented in this report. Three years (1966-1968) of hourly 10-min mean wind speed measurements were classified as a function of wind direction and periods of reference (annual, summer, winter, morning, daytime, evening, and nighttime). Cumulative percentage frequence distributions were computed with these data at seven tower levels to obtain percentiles of wind speed (50, 84.1, 97.8, and 99 percent). Data are also included to show the percentage frequency of wind speed observations by directions. These percentiles were chosen because they approximate for a normal distribution the mean and mean plus 1, 2, and 3 standard deviations, respectively. However, it should be recognized that the scalar wind distributions are not represented adequately by a normal distribution function but more appropriately by a Rayleigh distribution. The intent of this summarization of ground wind data is to provide a foundation for use in various aerospace vehicle related applications and to provide a general atmospheric description of wind flow in the lower 150-m for the Cape Kennedy/Merritt Island area.

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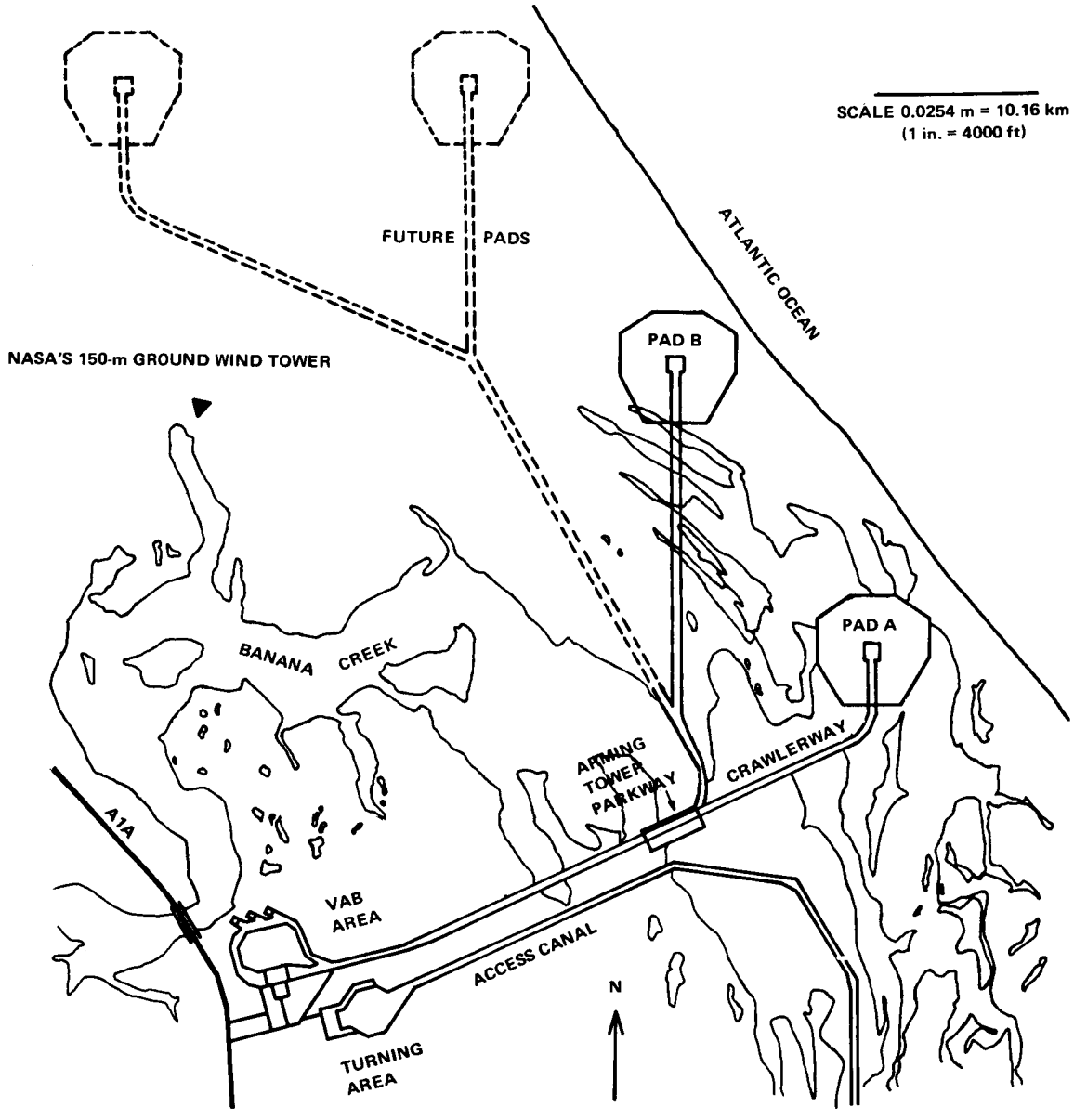

NASA'S 150-m GROUND WIND TOWER RELATIVE TO
NASA LAUNCH COMPLEX 39, KSC, FLORIDA

TECHNICAL MEMORANDUM X-64612

STATISTICAL DATA FROM NASA'S 150-m GROUND WIND TOWER AT KENNEDY SPACE CENTER, FLORIDA

SUMMARY

A statistical summary of ground wind data for the Kennedy Space Center, Florida recorded at NASA's 150-m Ground Wind Tower on Merritt Island is presented in this report. Three years (1966-1968) of hourly 10-min mean wind speed measurements were classified as a function of wind direction and periods of reference (annual, summer, winter, morning, daytime, evening, and nighttime). Cumulative percentage frequency distributions were computed with these data at seven tower levels to obtain percentiles of wind speed (50, 84.1, 97.8, and 99.9 percent). Data are also included to show the percentage frequency of wind speed observations by directions. The intent of this summarization of ground wind data is to provide a foundation for use in various aerospace vehicle related applications and to provide a general atmospheric description of wind flow in the lower 150-m for the Cape Kennedy/Merritt Island area.

INTRODUCTION

There are frequent and varied requirements for information describing wind conditions for the Kennedy Space Center (KSC) launch sites. A particular need may be related to on-pad space vehicle loading, atmospheric diffusion predictions of vehicle exhaust clouds, the preparation of space vehicle design criteria, operational planning, etc. This report provides detailed wind profile data which may be useful in some problem areas concerned with the ground wind environment in the area of KSC. Other published studies on this subject for the KSC area were made by Smith and Smith [1], Hill [2], and Daniels [3].

DATA

The 150-m Ground Wind Tower Facility located on Merritt Island, Florida about 4.83 km (3 mi.) west of Launch Complex 39 is the source of the wind data presented (see frontispiece). A detailed description of this facility and its operations is given by Kaufman and Keene [4]. The data are recorded continuously on analog paper strip charts and sent to the National Climatological Center, Asheville, N. C., for reduction. This manual reduction process will be replaced during 1971 by an Automatic Data Acquisition System (ADAS) being developed for the Marshall Space Flight Center.

Mean wind data from seven tower levels (3, 18, 30, 60, 90, 120, and 150 m) were analyzed in this report. More than 20 000 samples from each tower level were used, representing about 90 percent of the possible data for 3 years. Specifically, mean wind speeds and associated directions computed at ±5 min about the beginning of each hour were used. Each of these wind speed observations was categorized within 16 equal wind direction segments centered on the points of the compass. Abbreviations are used to indicate wind directions, such as winds from the north-northeast (NNE). The data were then grouped according to the time of day (2200-0400, 0500-0900, 1000-1600, and 1700-2100 EST) and according to season: winter (October-March) and summer (April-September). All data were used to obtain annual distributions. Cumulative percentage frequency distributions were computed with the 10-min means in each wind direction category according to the periods of reference listed. The percentage frequency of occurrence by directions of 10-min mean wind speed observations are given in Table 1. The results presented in Figures 1 through 49 show the 50, 84.1, 97.8, and 99.9 percentiles of each distribution. These percentiles were chosen because they approximate for a normal distribution the mean and mean plus 1, 2, and 3 standard deviations, respectively. However, it should be recognized that the scalar wind distributions are not represented adequately by a normal distribution function but more appropriately by a Rayleigh distribution.

DISCUSSION

This study used hourly 10-min mean wind data from three years (1966-1968). The distributions presented show many interesting features, especially at the 99.9 percentile level where some noticeable variability occurs because of the infrequent influence of tropical storms, severe thunderstorms, and active frontal systems. Specifically, tropical storms Alma (June 8-9, 1966) and Abby (June 4-6, 1968) provided several hours of high winds included in the sample. There were also cases when high speeds were measured at one tower level, 120-m level, for instance, but unfortunately, data were not recorded for the same time at another level; e.g., the 150-m level. This condition is often caused by lightning striking the top of the tower, resulting in the loss of wind instrumentation at the 150-m level. Such extreme data points were included and, consequently, may create some discontinuity when comparing level to level, especially at the 99.9-percent level unless the above is understood.

A considerable amount of statistical data on ground winds for the Kennedy Space Center is already available upon request from the Aerospace Environment Division of the Marshall Space Flight Center. A study of peak surface winds at Cape Kennedy was published by D. Lifsey in 1964 [5]. In addition, two studies have been completed describing thunderstorm probabilities by Falls, Williford, and Carter [6] and thunderstorm persistence by Lee, Dunkey, and Quinlan [7]. The probability of wind from tropical storms affecting Cape Kennedy is presented in a study prepared by the National Weather Service [8].

The following discussion describes some interesting features and trends seen from an examination of the 50th percentile wind speeds (Figs. 1 through 49) and the frequency of observations by wind directions at NASA's 150-m Ground Wind Tower Facility at KSC, Florida (Table 1). In general, the trends at the 50th percentile are reflected at the other percentiles presented (84.1, 97.8, and 99.9 percent).

The hourly 10-min means of wind speeds are recorded most frequently on an annual basis from the east (i.e., NE-SE) and least frequently from the west (i.e., WSW-NW) at all tower levels. The smallest 50th percentile values occur when the wind is westerly with a southerly component (i.e., SSW-WSW), while the largest values are associated with north and northwest winds.

The 50th percentile wind speeds from the annual distributions relative to direction range from a minimum of 1.9 $m\text{-}s^{-1}$ at the 3-m level from west-southwest (Fig. 43) to 7.9 m/s from north-northwest at the 150-m level (Fig. 1).

Summer winds (April-September) are measured most often from the southeast, while winter winds show a maximum occurrence from the northwest at all tower levels. During the summer, the dominance of the Atlantic anticyclone and the sea breeze combined to produce persistent periods of southeasterly flow. Cold anticyclonic flow during the winter from systems moving through the central and eastern United States causes many hours of northwesterly winds.

The wind direction showing the least frequency of occurrence in the summer is northwest (i.e., WNW-NNW), and in the winter the fewest observations are measured from west-southwest. Winter winds produce higher 50th percentile speeds than summer winds, particularly, at the upper levels of the tower. The wind direction showing the greatest number of observations in the morning hours is northwest at most tower levels. This trend changes to northeast during mid-day, to southeast late in the afternoon and early evening, then to south during the middle of the night. This common pattern reflects the dominant influence of the land-sea breeze. At NASA's 150-m Ground Wind Tower, the wind seldom flows from the southeast during the early morning, the west during the daytime and evening, or the northeast at night. The smallest 50th percentile speeds were usually from west-southwest; however, some of the highest wind speeds occurred from the north and northwest, indicating the influence of high winds from thunderstorms.

Additional years of data will soon be available from NASA's 150-m Ground Wind Tower Facility, which will provide more information about the long-time means and extremes of wind speeds and associated directions.

TABLE 1. PERCENTAGE FREQUENCY OF OCCURRENCE BY DIRECTIONS OF 10-MIN AVERAGES OF WIND SPEEDS FOR NASA'S 150-m GROUND WIND TOWER, KSC, FLORIDA

150-m Level							
Wind Dir. Deg	Period of Reference (%)						
	Annual	Summer	Winter	0500-0900 EST	1000-1600 EST	1700-2100 EST	2200-0400 EST
12-33	6.1	4.6	7.6	4.9	8.2	6.8	4.0
34-56	6.6	6.2	6.9	5.2	7.9	7.5	5.4
57-78	6.8	6.2	7.6	5.5	8.3	8.5	5.4
79-101	8.1	9.3	6.9	5.9	9.5	8.6	7.7
102-123	6.6	8.6	4.8	4.9	7.7	7.6	5.8
124-146	8.8	11.2	6.9	5.1	8.9	13.5	8.1
147-168	7.4	8.7	6.2	5.3	4.9	10.9	8.7
169-191	6.4	7.5	5.2	7.5	3.9	5.2	9.1
192-213	5.4	7.3	3.5	7.2	3.5	3.2	7.5
214-236	5.8	8.1	3.7	7.8	5.1	3.5	6.9
237-258	4.2	6.0	2.5	5.9	3.9	2.5	4.5
259-281	4.5	4.0	4.8	4.3	3.9	5.1	4.8
282-303	4.4	2.6	6.1	4.9	4.2	3.4	5.1
304-326	4.3	2.0	6.2	6.8	2.8	2.3	5.5
327-348	6.5	2.7	10.2	9.2	7.4	3.8	5.5
349-011	7.9	4.8	10.7	9.1	9.9	7.6	5.7
Calm	0.2	0.2	0.2	0.5	< 0.1	< 0.1	0.4
120-m Level							
12-33	6.7	5.1	8.1	5.1	8.9	7.2	3.9
34-56	6.7	6.4	6.9	5.9	7.8	7.3	5.5
57-78	7.3	6.9	7.7	5.6	9.2	8.6	5.5
79-101	7.9	9.1	6.8	5.9	9.3	8.4	7.4
102-123	6.9	8.7	5.1	4.7	7.9	8.2	6.4
124-146	8.4	10.9	5.9	4.3	8.6	12.9	7.8
147-168	7.3	8.7	6.0	5.1	5.2	11.3	8.3
169-191	6.4	7.4	5.4	7.1	3.9	5.6	8.9
192-213	5.4	7.2	3.7	7.6	3.5	3.1	7.8
214-236	5.6	7.7	3.5	7.7	4.4	3.3	7.2
237-258	4.6	6.1	2.9	6.5	4.1	2.5	4.9
259-281	4.4	3.9	5.0	4.7	4.0	4.7	4.6
282-303	4.4	2.6	6.2	4.6	4.3	3.6	4.9
304-326	4.1	1.8	6.4	6.2	2.6	2.2	5.6
327-048	6.3	2.7	9.7	9.4	6.8	3.2	4.8
349-011	7.6	4.8	10.8	9.5	9.5	7.9	6.4
Calm	< 0.1	< 0.1	< 0.1	0.2	0.0	0.0	0.1

TABLE 1. (Continued)

Wind Dir. Deg	Annual	Summer	Winter	0500-0900 EST	1000-1600 EST	1700-2100 EST	2200-0400 EST
	Period of Reference (%)						
90-m Level							
12-33	7.0	4.8	8.8	4.9	9.6	7.7	4.9
34-56	6.6	6.8	6.6	5.2	8.2	7.7	5.6
57-78	7.1	6.9	7.4	5.5	8.9	7.9	5.7
79-101	7.6	8.5	6.7	6.3	8.7	8.4	6.6
102-123	6.9	8.9	5.1	4.5	7.9	8.4	6.7
124-146	8.2	10.3	6.1	4.5	8.4	12.5	7.2
147-168	7.8	9.5	6.2	4.9	5.3	12.4	9.0
169-191	5.9	6.9	4.8	6.4	4.1	4.9	8.0
192-213	5.8	7.7	3.9	8.3	3.6	3.1	8.3
214-236	5.5	7.0	3.9	7.1	4.9	3.1	6.7
237-258	4.3	6.0	2.7	6.6	3.8	2.1	5.0
259-281	4.1	3.9	4.3	4.6	3.9	3.8	4.2
282-303	4.3	2.8	5.8	4.3	4.0	3.6	5.2
304-326	4.7	2.0	7.3	7.2	3.0	2.5	6.3
327-348	6.2	2.1	9.7	9.6	6.1	3.7	5.0
349-011	7.9	5.9	10.5	9.9	9.6	8.2	5.3
Calm	0.1	< 0.1	0.2	0.2	< 0.1	< 0.1	0.3
60-m Level							
12-33	6.3	5.3	7.1	4.7	9.2	7.0	3.3
34-56	6.6	6.4	7.1	5.3	7.9	8.1	5.4
57-78	7.2	6.5	7.8	5.8	9.2	7.8	5.7
79-101	7.8	8.8	6.7	5.9	8.9	8.1	7.1
102-123	6.5	8.5	4.4	4.4	7.2	8.4	5.8
124-146	8.8	11.5	5.9	4.9	9.6	12.9	7.6
147-168	7.8	9.2	6.4	4.4	5.2	12.3	9.5
169-191	5.9	7.2	4.6	6.4	4.1	4.9	8.3
192-213	5.8	7.6	4.1	9.1	3.4	3.4	8.0
214-236	5.5	7.3	3.9	7.5	4.4	3.3	6.6
237-258	4.4	6.0	2.9	6.3	4.2	2.0	5.2
259-281	4.3	3.7	4.8	4.9	3.4	4.0	4.9
282-303	4.7	2.8	6.5	4.9	4.7	3.6	5.3
304-326	5.0	1.9	8.2	8.4	2.9	2.4	6.7
327-348	5.9	2.1	9.3	9.3	6.9	4.1	3.7
349-011	7.4	5.1	10.6	7.8	9.4	7.1	6.5
Calm	0.1	0.1	0.2	< 0.1	< 0.1	< 0.1	0.4

TABLE 1. (Continued)

Wind Dir. Deg	Annual	Summer	Winter	0500-0900 EST	1000-1600 EST	1700-2100 EST	2200-0400 EST
	Period of Reference (%)						
30-m Level							
12-33	6.8	5.2	7.7	4.3	9.0	7.3	3.7
34-56	6.5	6.6	6.3	5.1	7.9	7.6	5.1
57-78	7.2	6.9	7.6	5.6	9.4	7.9	5.4
79-101	8.1	9.4	6.8	5.7	9.9	8.8	7.2
102-123	6.9	9.2	4.5	4.6	7.2	9.1	6.5
124-146	7.8	9.9	5.6	4.4	9.2	11.7	5.8
147-168	7.8	9.6	6.2	4.7	4.9	12.8	9.7
169-191	5.9	6.8	4.9	6.6	4.2	4.9	7.9
192-213	6.3	8.1	4.4	8.9	3.7	3.4	9.2
214-236	5.1	6.8	3.4	6.9	4.4	3.1	6.2
237-258	4.0	5.1	2.9	5.9	3.6	1.8	4.8
259-281	4.4	3.7	5.0	4.5	3.6	4.3	5.2
282-303	4.6	2.7	6.4	5.5	4.1	3.2	5.5
304-326	5.8	2.5	9.2	10.5	2.9	3.0	7.5
327-348	6.1	2.0	9.4	8.3	6.2	3.7	3.7
349-011	6.6	5.3	9.6	8.4	9.8	7.3	6.4
Calm	0.1	0.2	0.1	0.2	0.0	0.1	0.2
18-m Level							
12-33	6.8	5.3	7.7	4.1	9.4	7.2	3.7
34-56	6.5	6.4	6.6	5.3	8.3	7.3	5.1
57-78	7.2	6.8	7.5	5.9	8.9	8.4	5.5
79-101	6.9	8.4	5.5	5.1	8.6	7.4	6.3
102-123	7.2	9.6	4.7	4.6	7.7	9.5	6.6
124-146	6.9	9.4	4.5	3.9	8.8	10.3	4.5
147-168	7.3	9.1	5.6	4.0	4.6	12.1	8.8
169-191	5.9	6.9	4.9	5.3	4.6	5.9	7.5
192-213	6.1	7.8	4.2	9.2	3.5	3.2	8.5
214-236	5.5	7.4	3.4	6.9	4.4	3.5	6.8
237-258	4.2	5.1	3.3	6.0	3.7	1.9	5.1
259-281	4.5	3.9	5.0	5.0	3.5	4.1	5.5
282-303	5.1	3.1	7.0	6.1	4.3	3.4	6.4
304-326	6.2	2.7	9.8	11.9	3.2	3.2	7.8
327-348	6.5	2.6	9.6	7.5	6.8	4.9	4.4
349-011	7.0	5.3	10.4	8.9	9.7	7.7	7.2
Calm	0.2	0.2	0.3	0.3	<0.1	<0.1	0.3

TABLE 1. (Concluded)

3-m Level							
Wind Dir. Deg	Period of Reference (%)						
	Annual	Summer	Winter	0500-0900 EST	1000-1600 EST	1700-2100 EST	2200-0400 EST
12-33	5.5	5.1	6.7	3.9	8.6	6.0	3.6
34-56	5.4	5.5	5.4	3.7	8.2	6.1	3.3
57-78	6.2	6.4	5.9	4.8	8.6	6.8	4.0
79-101	7.3	8.5	5.8	5.5	10.2	7.4	5.4
102-123	6.5	8.3	4.4	4.1	7.0	9.3	5.6
124-146	7.2	9.4	4.9	3.8	10.2	10.5	4.3
147-168	7.8	9.0	6.4	4.3	5.4	13.3	8.9
169-191	6.9	7.7	6.2	6.2	5.3	8.1	8.6
192-213	5.8	6.7	4.4	8.3	3.8	3.6	7.4
214-236	6.5	8.2	4.3	8.4	5.4	3.4	8.5
237-258	4.4	5.2	3.2	6.2	3.7	2.3	5.2
259-281	4.9	4.3	5.6	5.2	3.6	4.2	6.8
282-303	5.3	3.2	7.6	6.1	4.0	4.2	6.6
304-326	6.0	2.7	10.0	12.0	2.6	3.1	7.7
327-348	4.8	2.7	8.1	7.7	5.4	3.7	3.8
349-011	7.0	4.5	8.3	5.9	8.0	6.6	5.0
Calm	2.5	2.6	2.8	3.9	<0.1	1.4	5.3

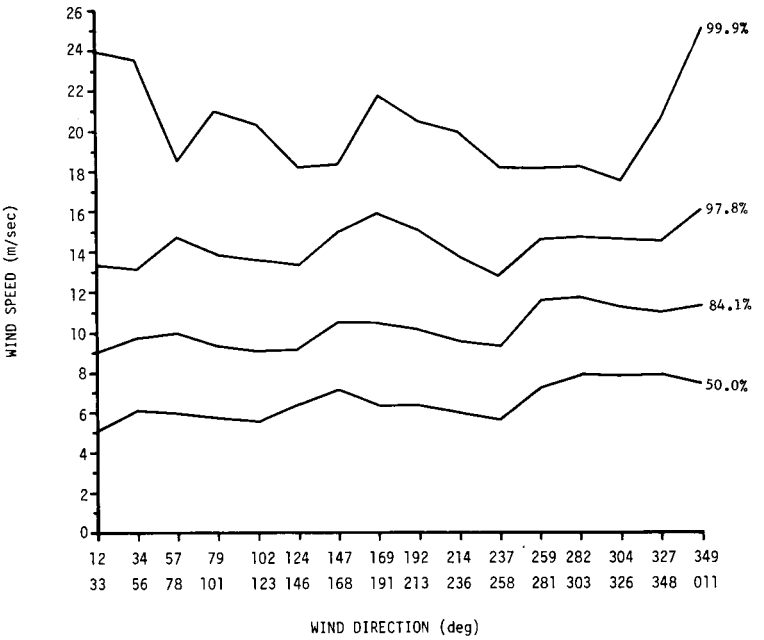

Figure 1. Annual percentile distribution of 10-min average wind speed data as a function of wind direction for the 150-m level.

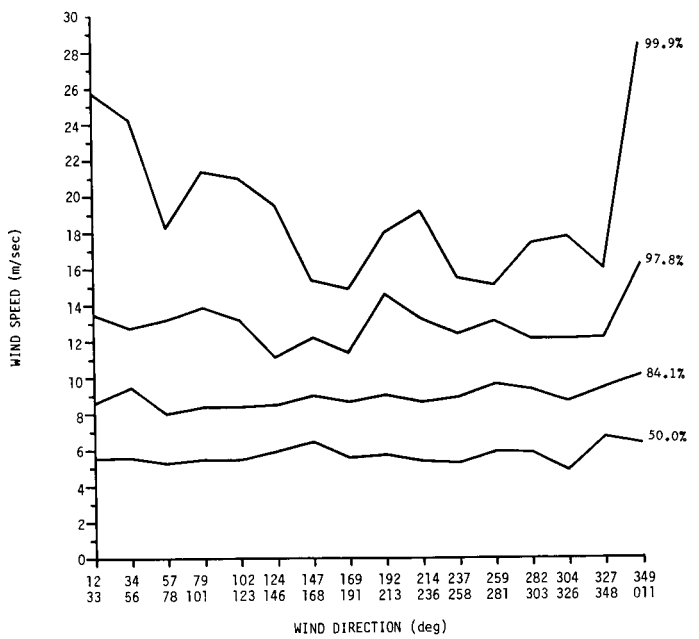

Figure 2. Summer (Apr.-Sep.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 150-m level.

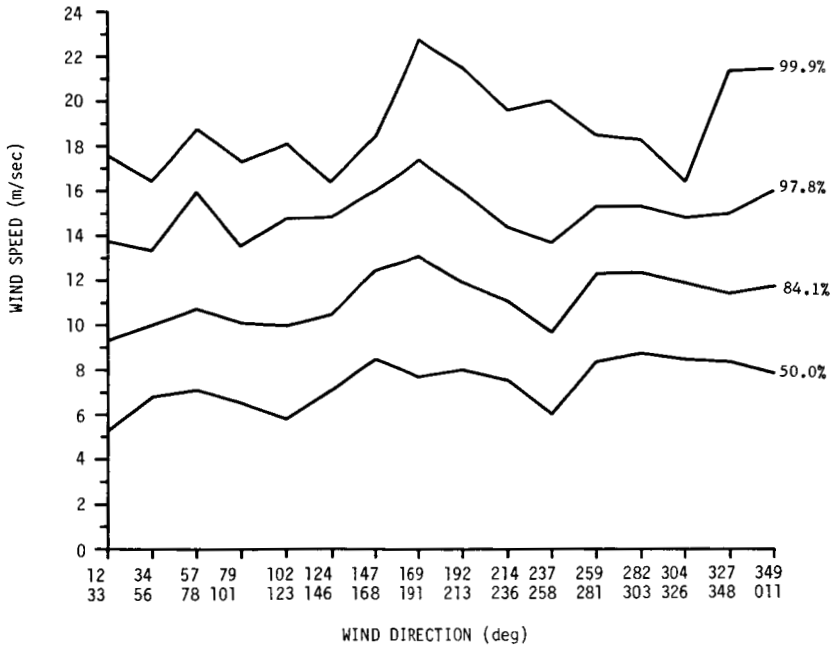

Figure 3. Winter (Oct.-Mar.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 150-m level.

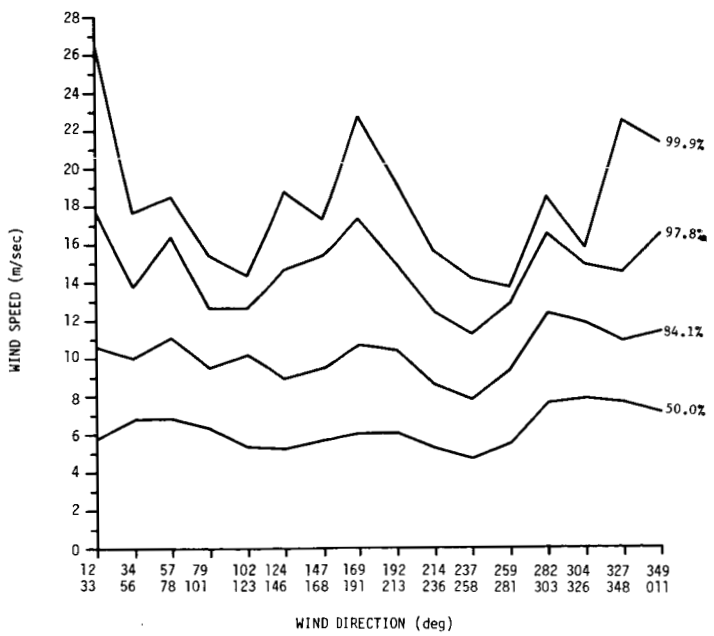

Figure 4. Morning (0500-0900 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 150-m level.

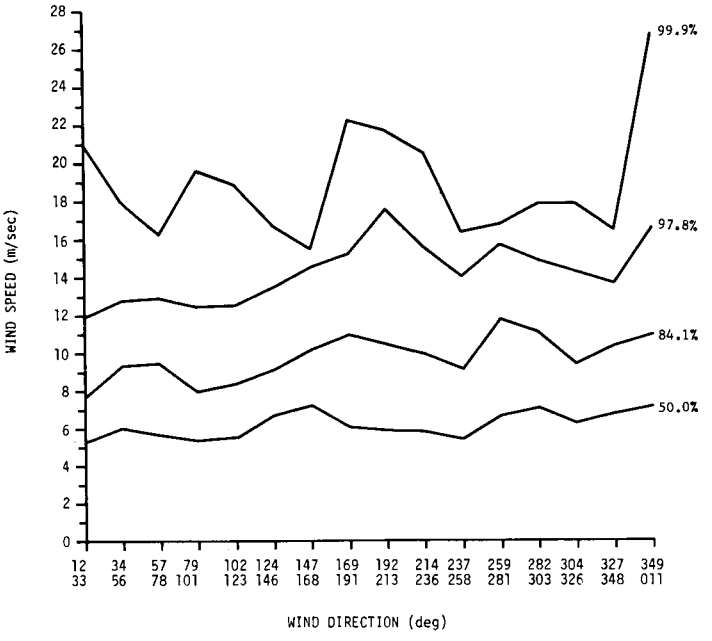

Figure 5. Daytime (1000-1600 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 150-m level.

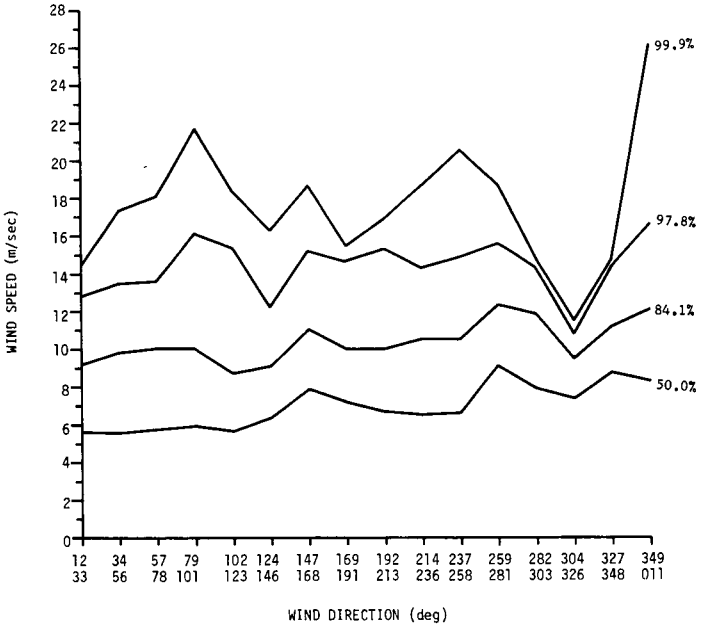

Figure 6. Evening (1700-2100 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 150-m level.

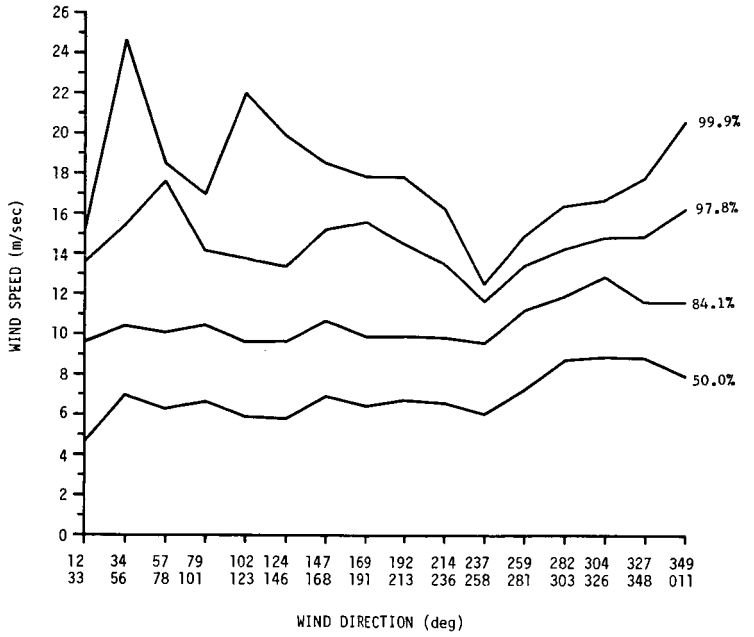

Figure 7. Nighttime (2200-0400 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 150-m level.

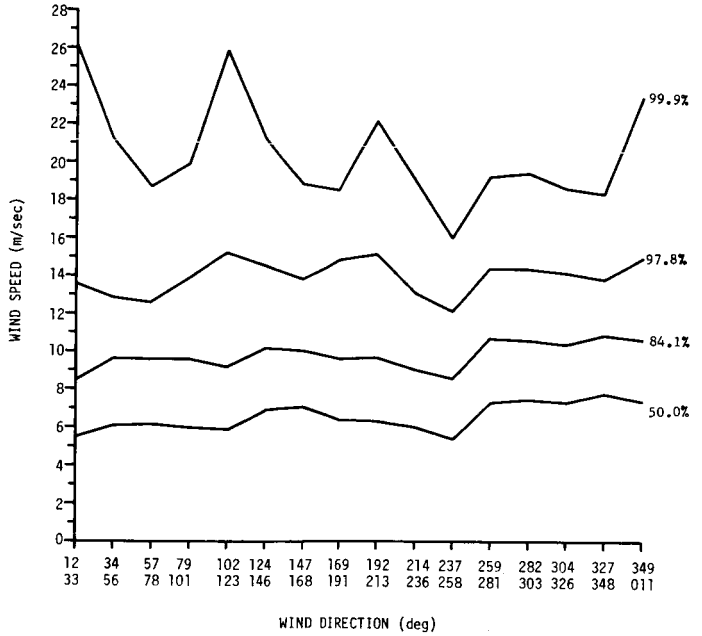

Figure 8. Annual percentile distribution of 10-min average wind speed data as a function of wind direction for the 120-m level.

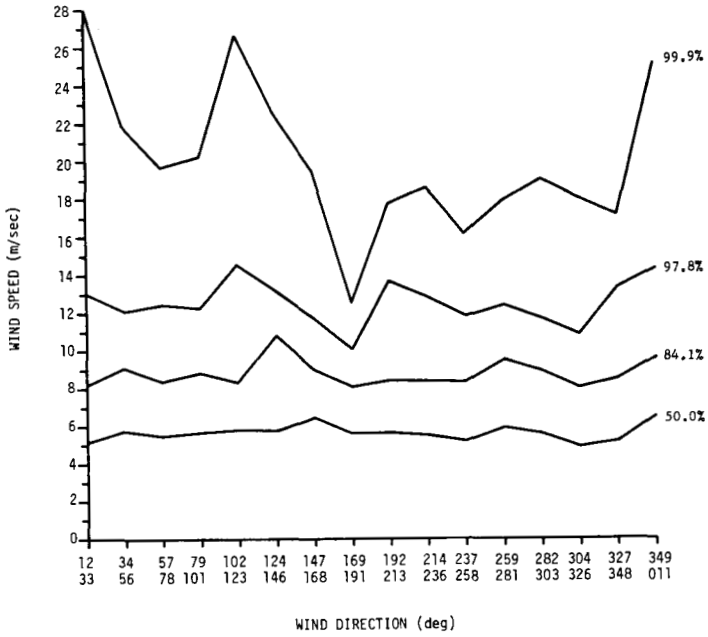

Figure 9. Summer (Apr.-Sep.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 120-m level.

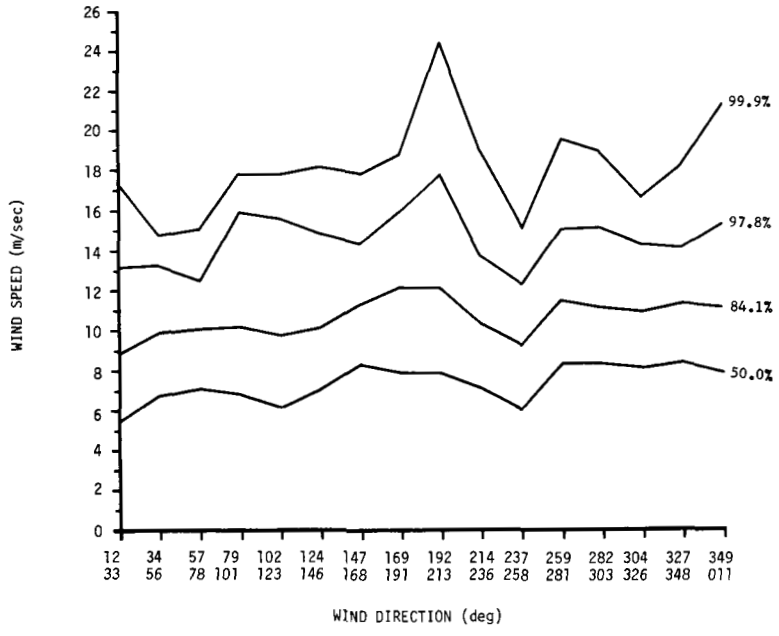

Figure 10. Winter (Oct.-Mar.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 120-m level.

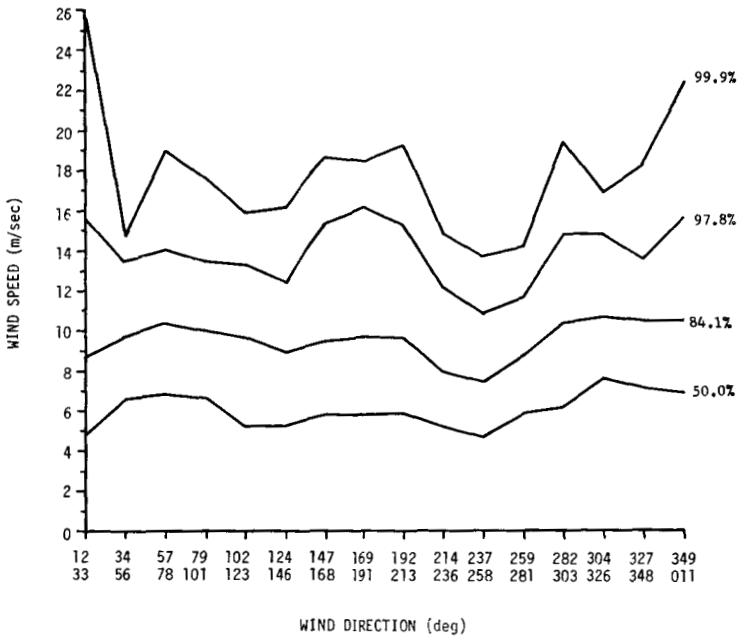

Figure 11. Morning (0500-0900 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 120-m level.

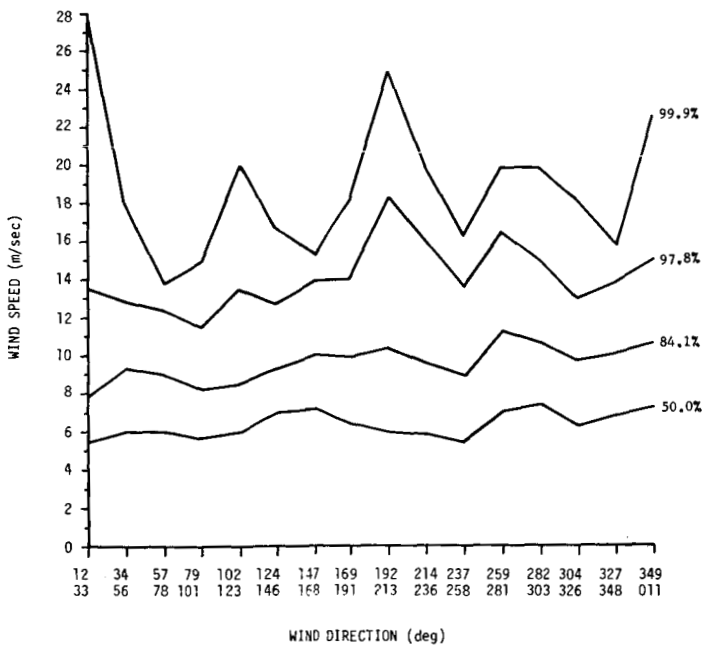

Figure 12. Daytime (1000-1600 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 120-m level.

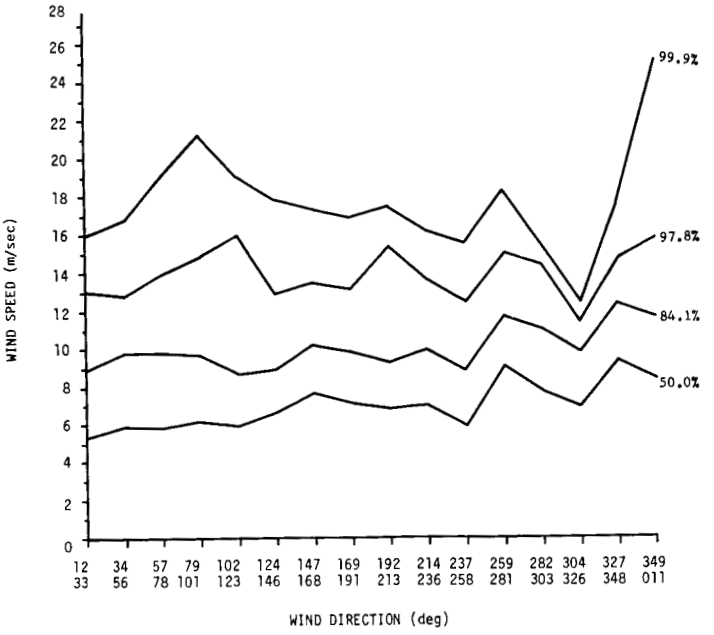

Figure 13. Evening (1700-2100 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 120-m level.

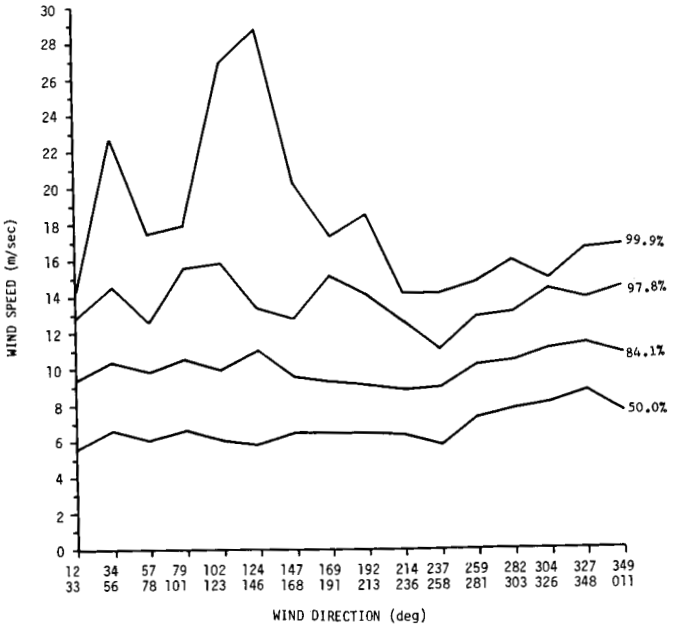

Figure 14. Nighttime (2200-0400 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 120-m level.

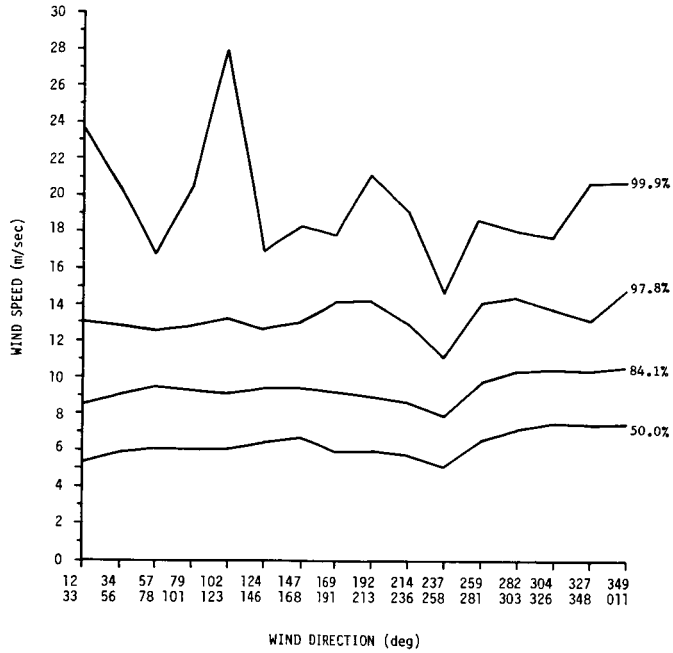

Figure 15. Annual percentile distribution of 10-min average wind speed data as a function of wind direction for the 90-m level.

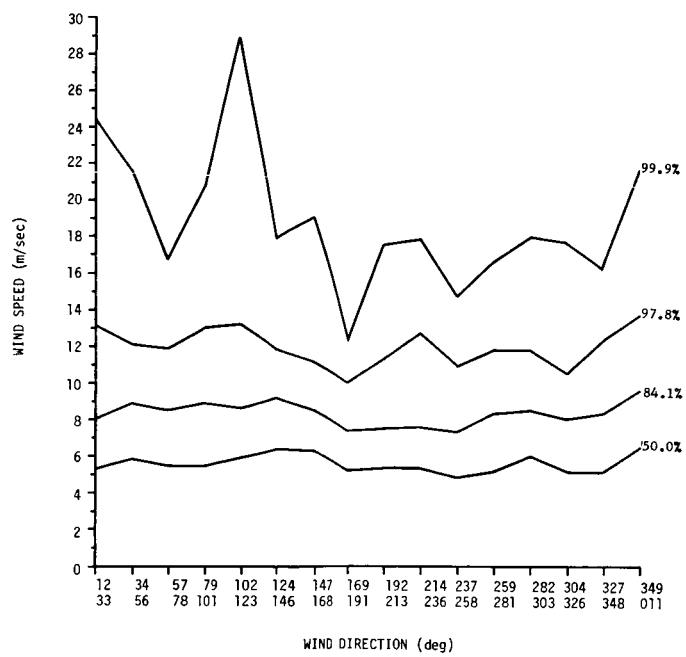

Figure 16. Summer (Apr.-Sep.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 90-m level.

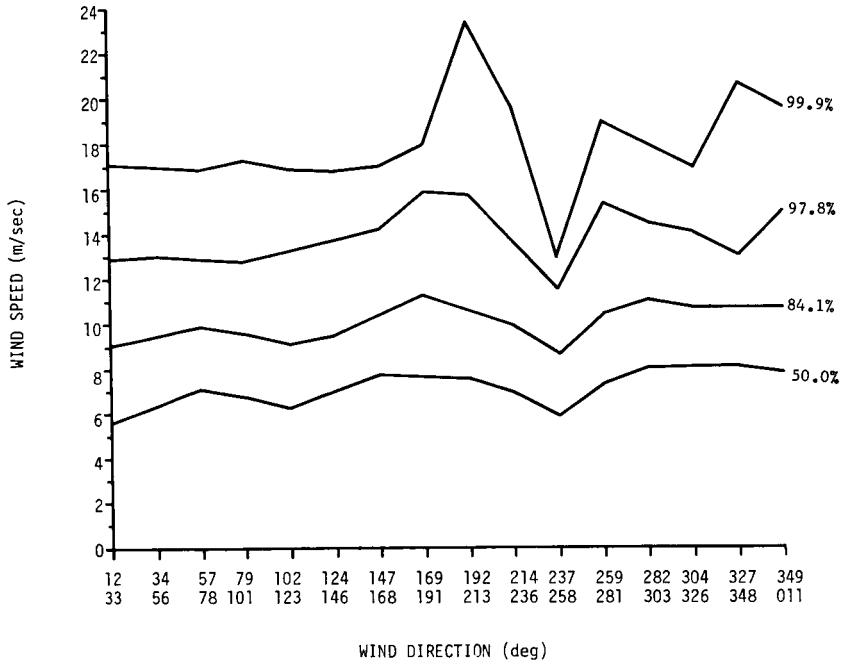

Figure 17. Winter (Oct.-Mar.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 90-m level.

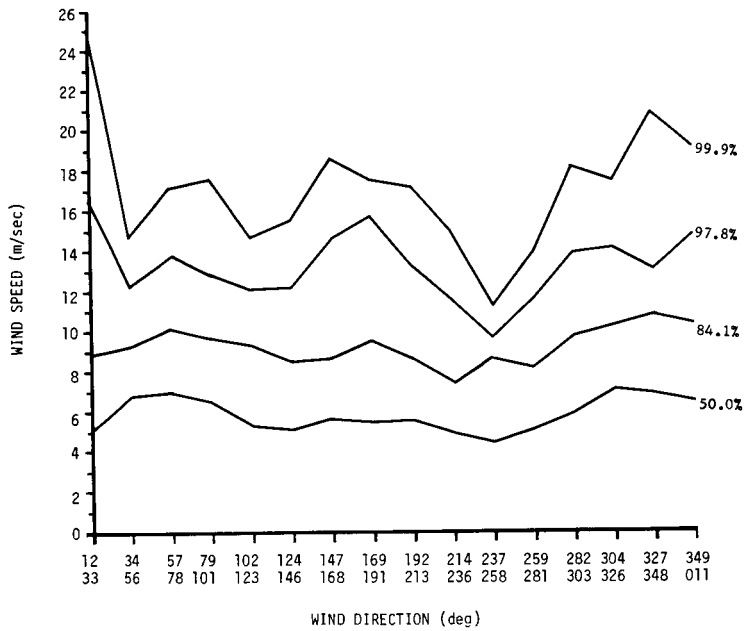

Figure 18. Morning (0500-0900 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 90-m level.

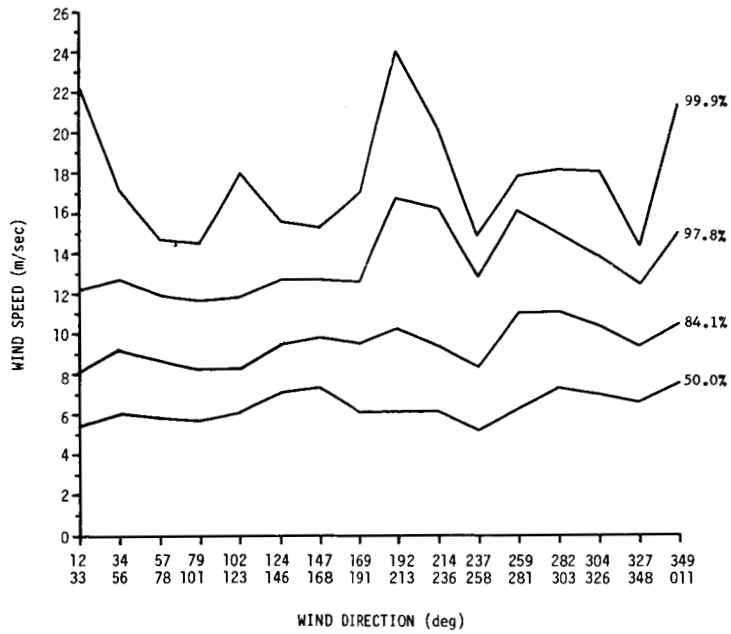

Figure 19. Daytime (1000-1600 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 90-m level.

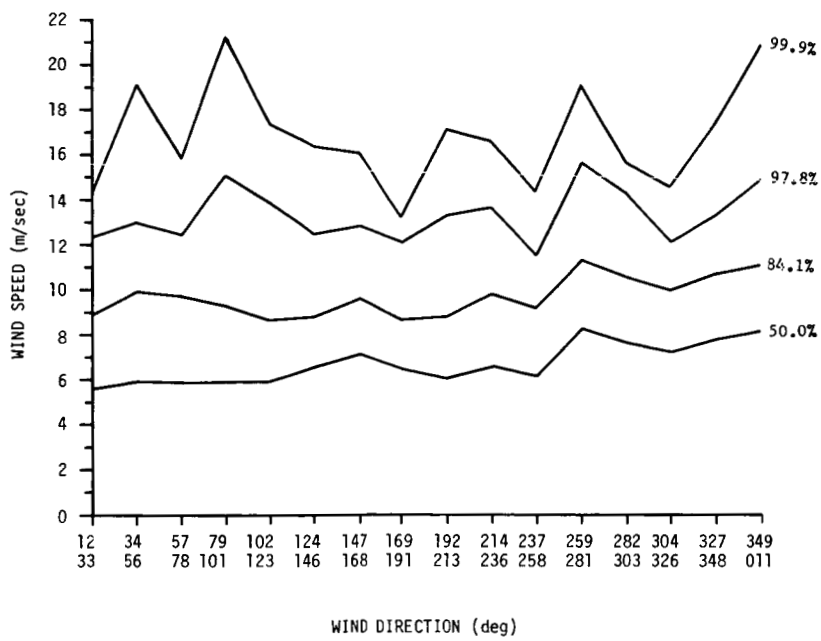

Figure 20. Evening (1700-2100 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 90-m level.

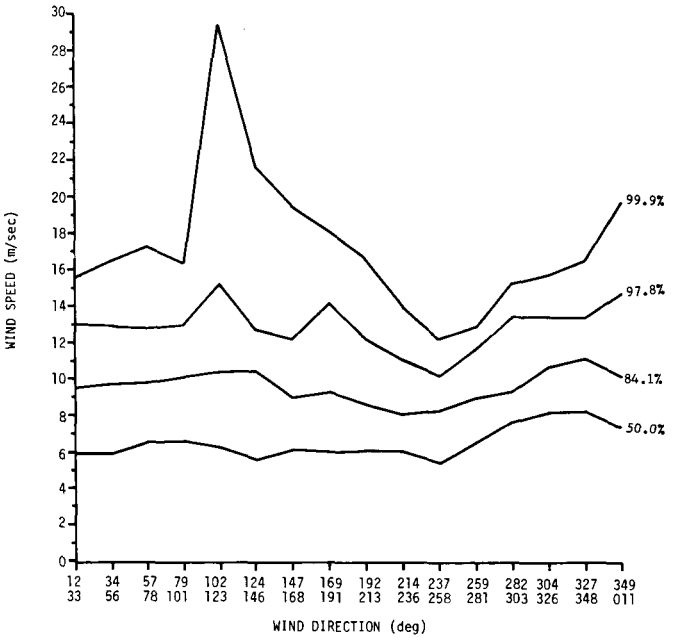

Figure 21. Nighttime (2200-0400 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 90-m level.

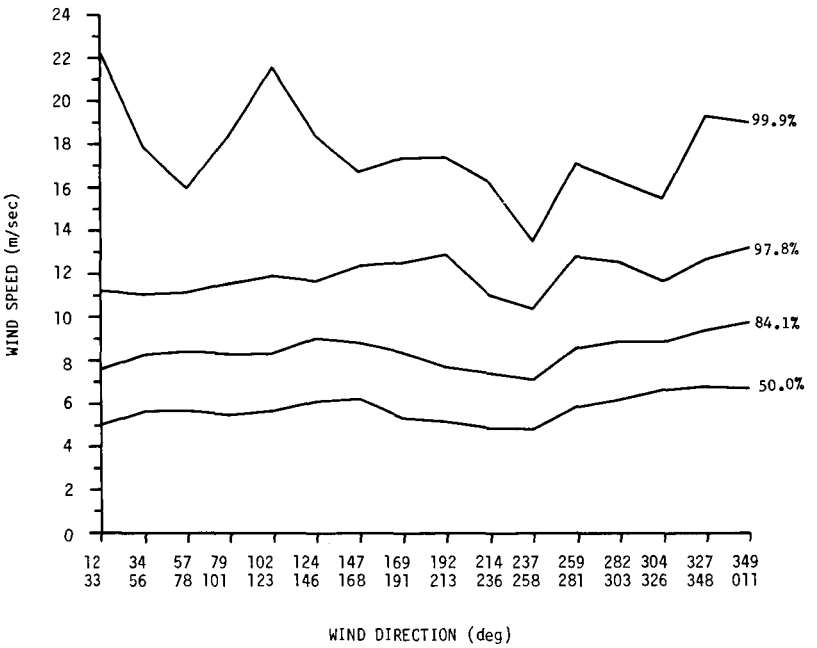

Figure 22. Annual percentile distribution of 10-min average wind speed data as a function of wind direction for the 60-m level.

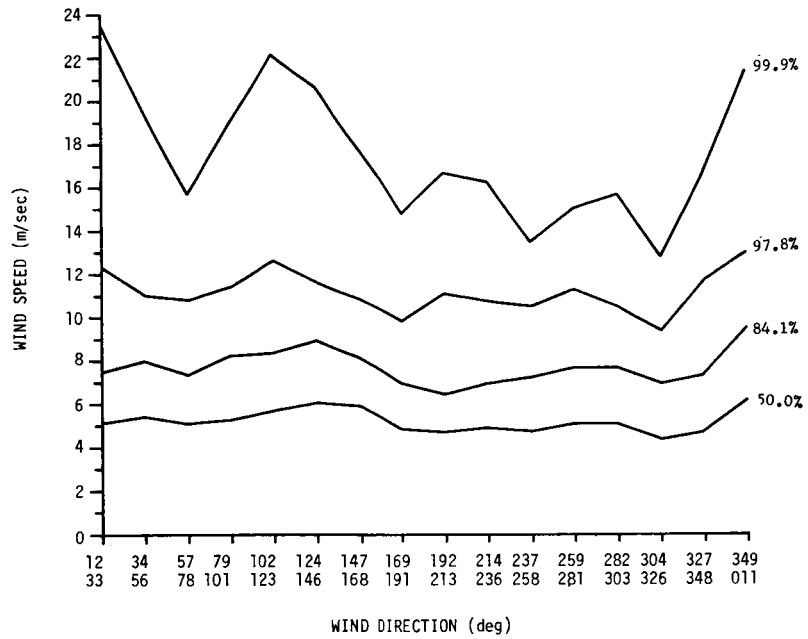

Figure 23. Summer (Apr.-Sep.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 60-m level.

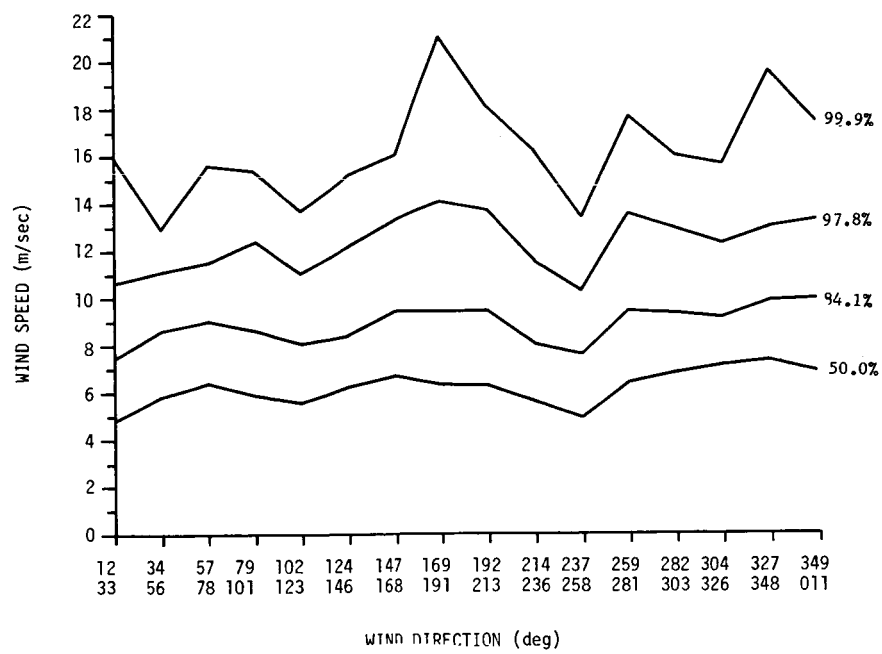

Figure 24. Winter (Oct.-Mar.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 60-m level.

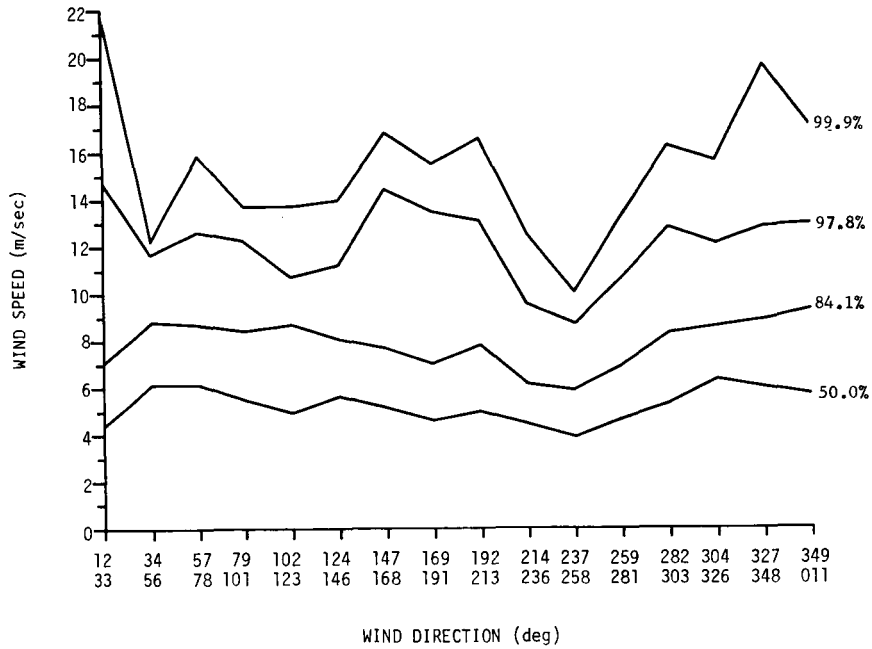

Figure 25. Morning (0500-0900 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 60-m level.

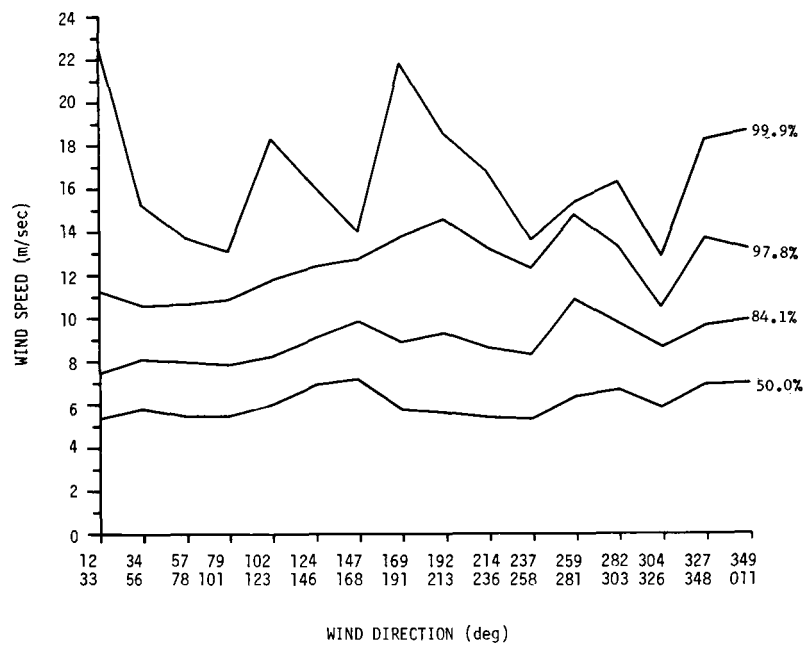

Figure 26. Daytime (1000-1600 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 60-m level.

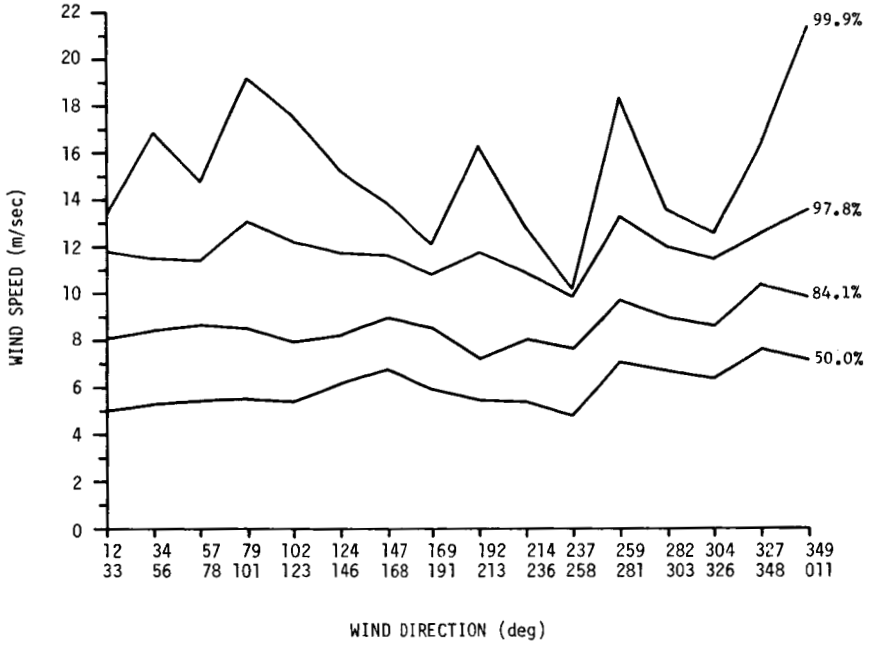

Figure 27. Evening (1700-2100 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 60-m level.

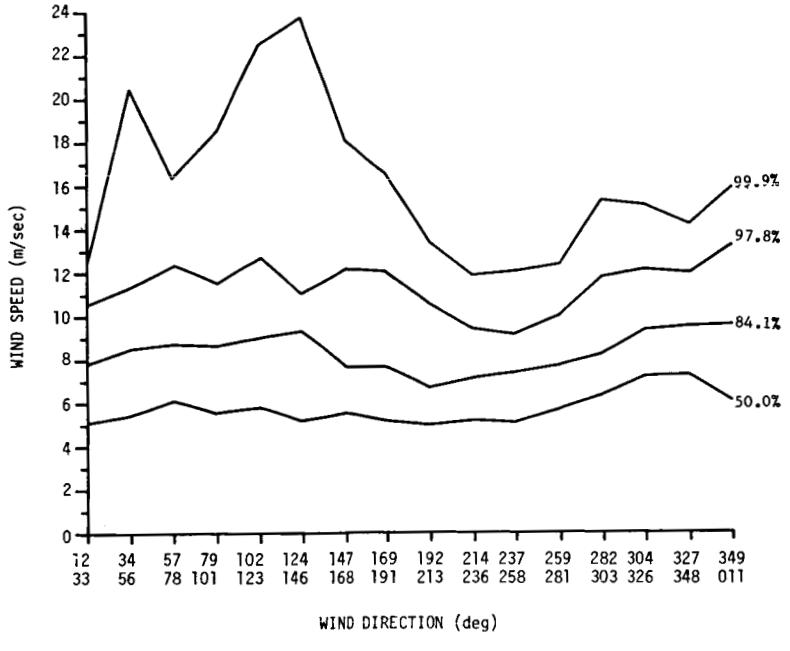

Figure 28. Nighttime (2200-0400 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 60-m level.

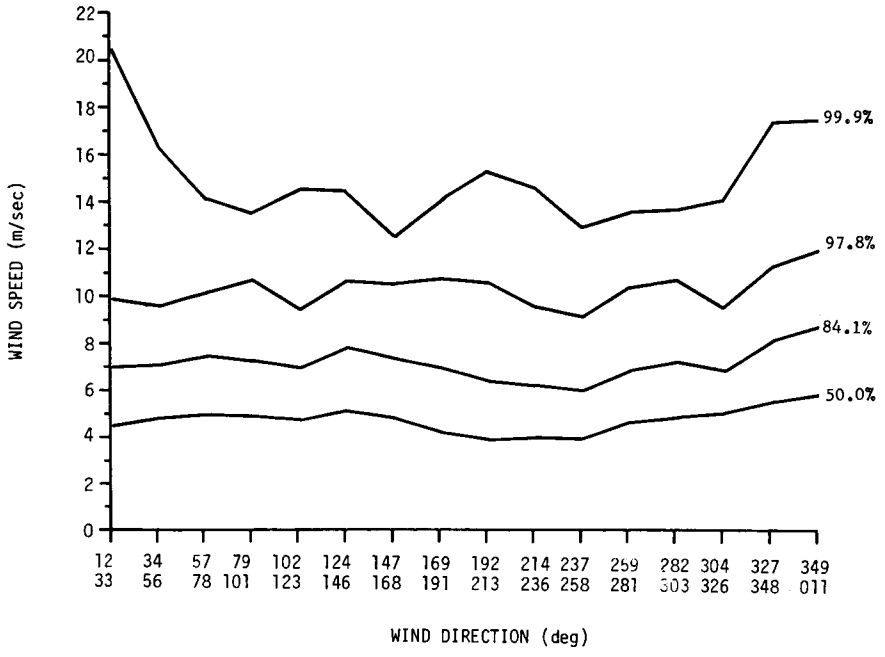

Figure 29. Annual percentile distribution of 10-min average wind speed data as a function of wind direction for the 30-m level.

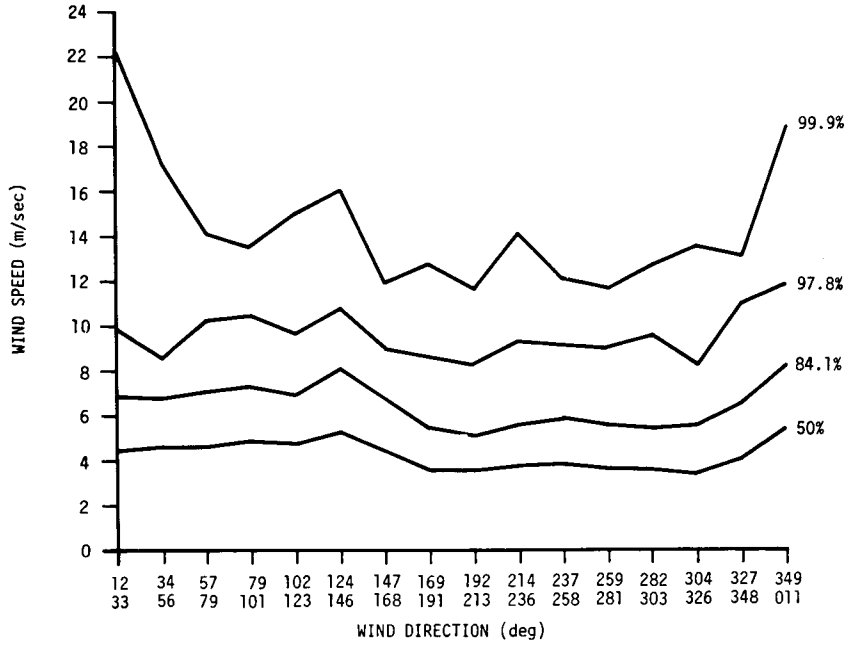

Figure 30. Summer (Apr.-Sep.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 30-m level.

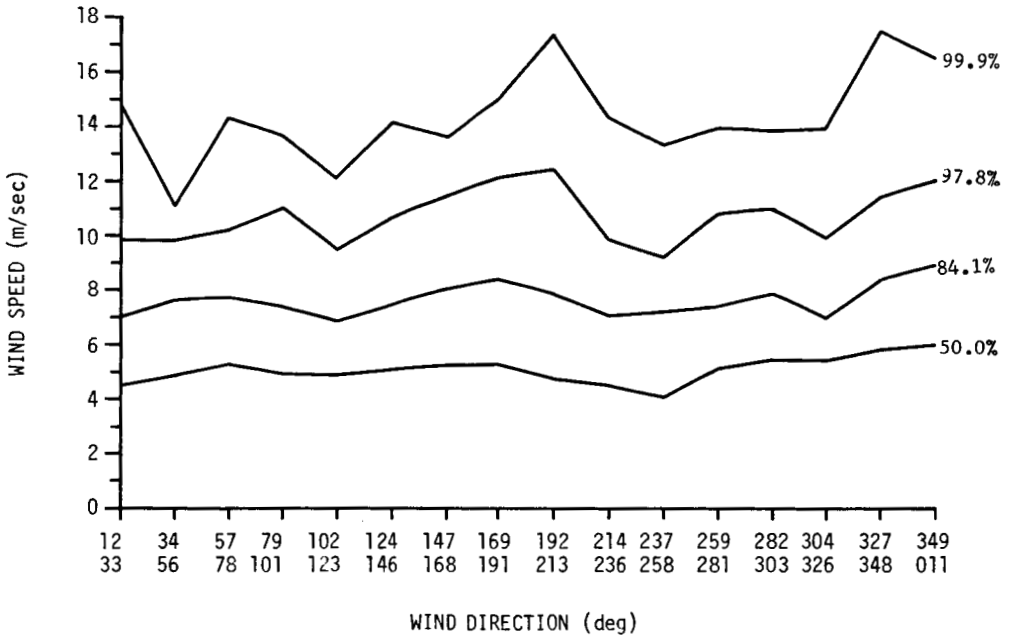

Figure 31. Winter (Oct.-Mar.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 30-m level.

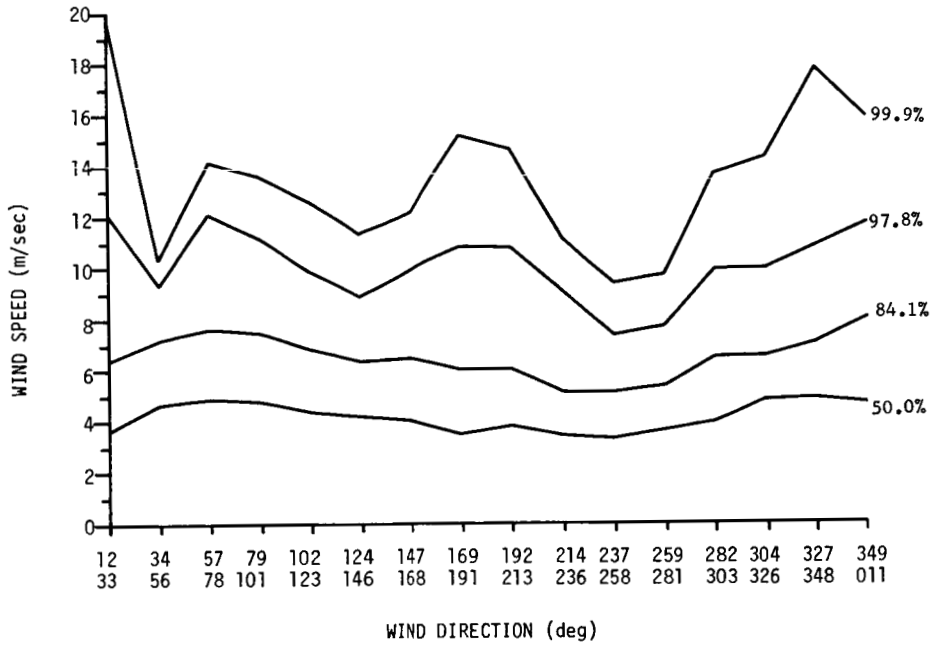

Figure 32. Morning (0500-0900 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 30-m level.

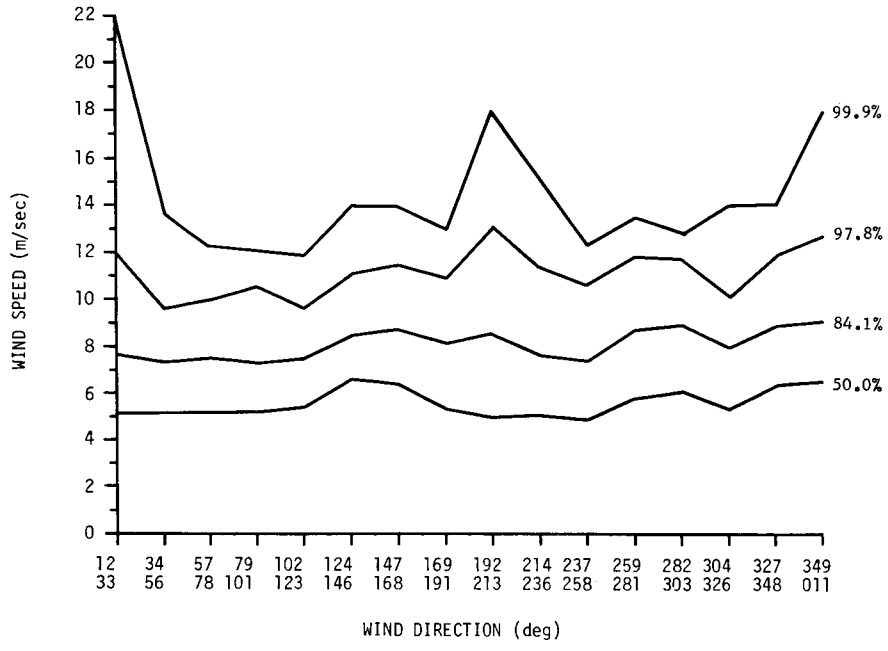

Figure 33. Daytime (1000-1600 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 30-m level.

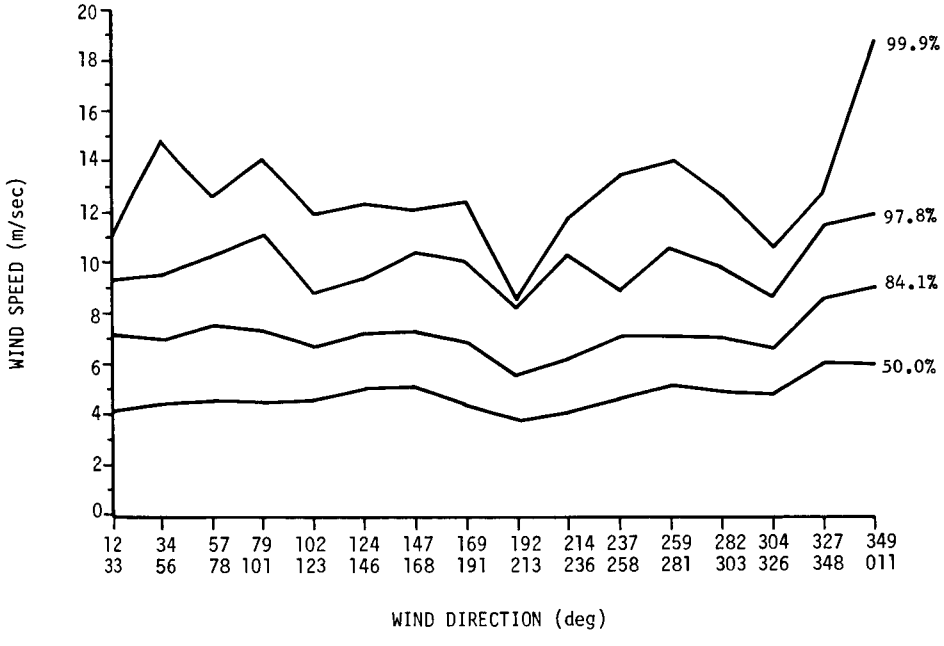

Figure 34. Evening (1700-2100 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 30-m level.

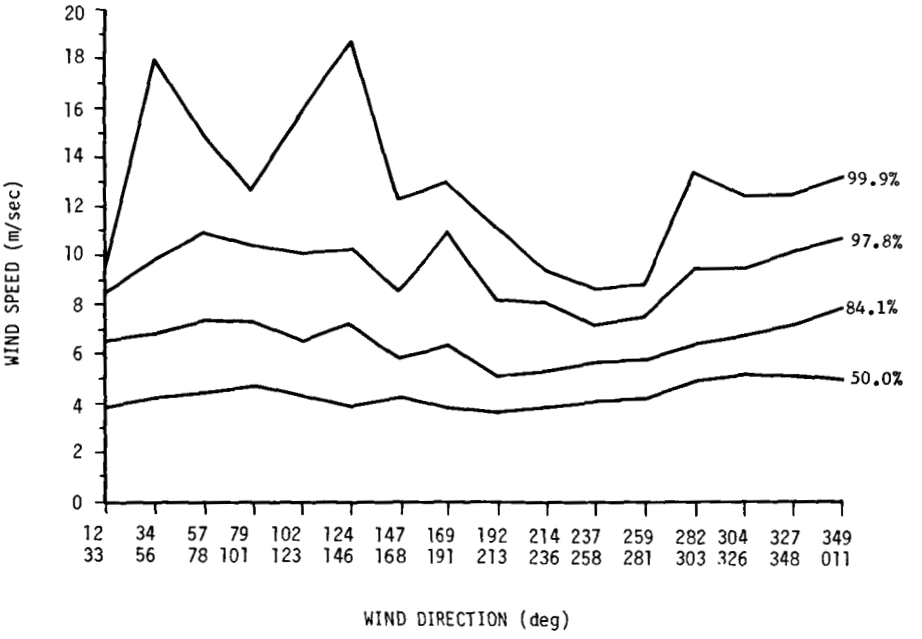

Figure 35. Nighttime (2200-0400 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 30-m level.

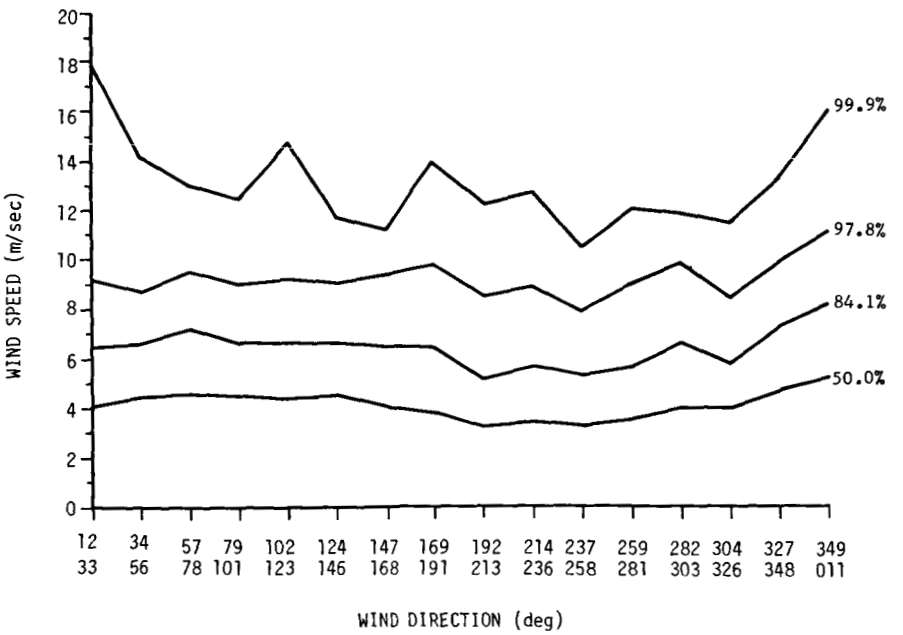

Figure 36. Annual percentile distribution of 10-min average wind speed data as a function of wind direction for the 18-m level.

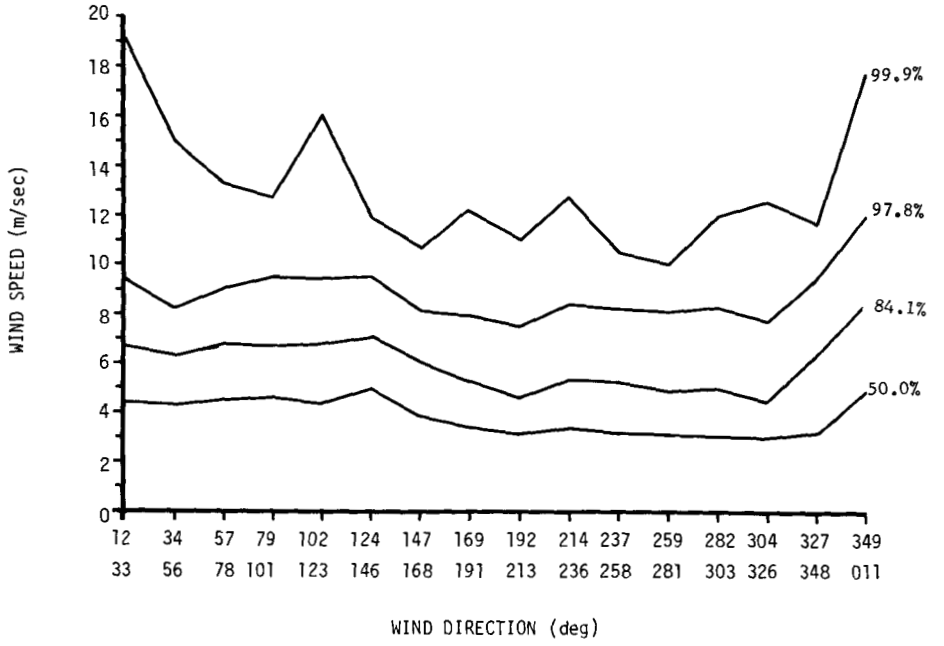

Figure 37. Summer (Apr.-Sep.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 18-m level.

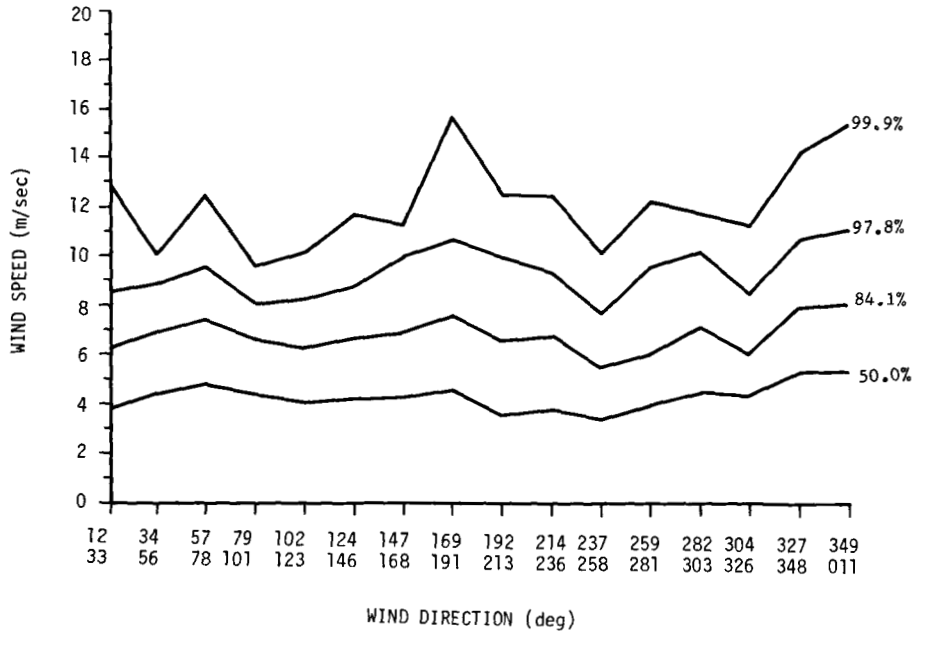

Figure 38. Winter (Oct.-Mar.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 18-m level.

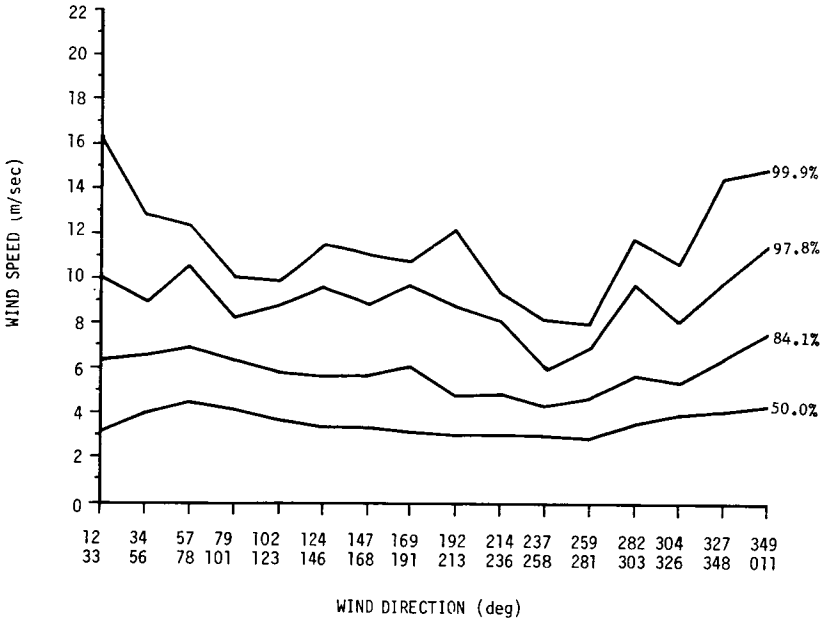

Figure 39. Morning (0500-0900 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 18-m level.

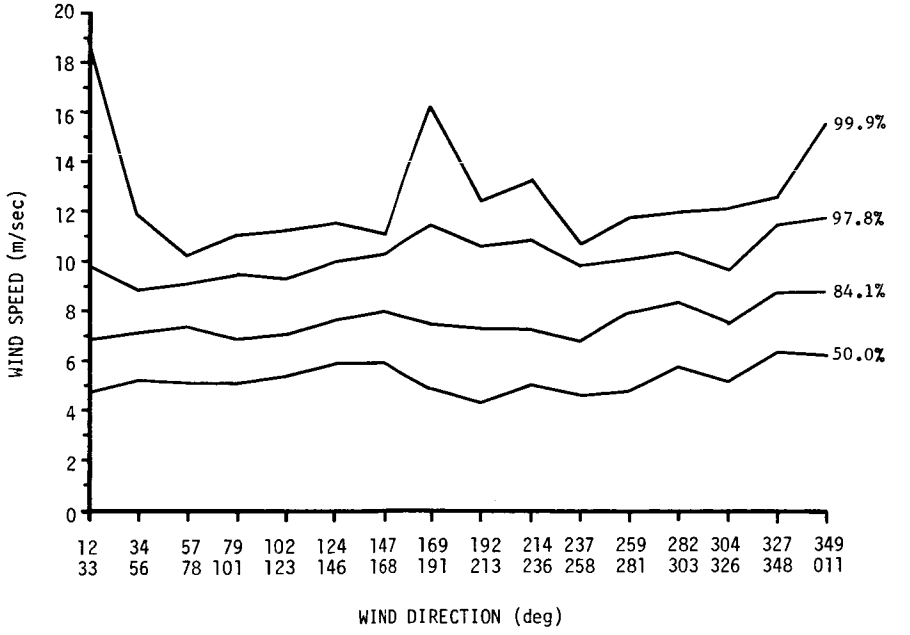

Figure 40. Daytime (1000-1600 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 18-m level.

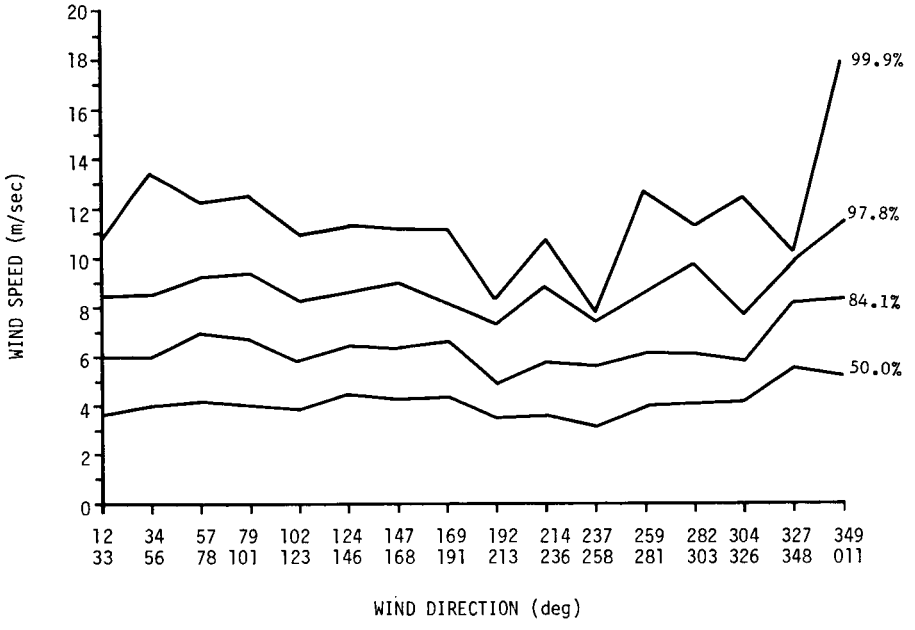

Figure 41. Evening (1700-2100 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 18-m level.

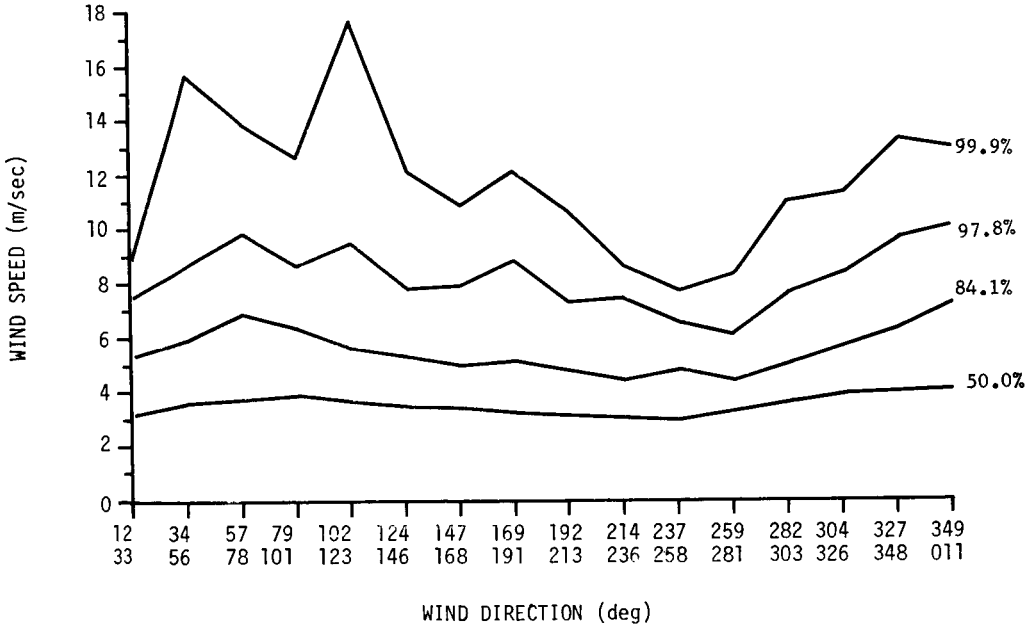

Figure 42. Nighttime (2200-0400 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 18-m level.

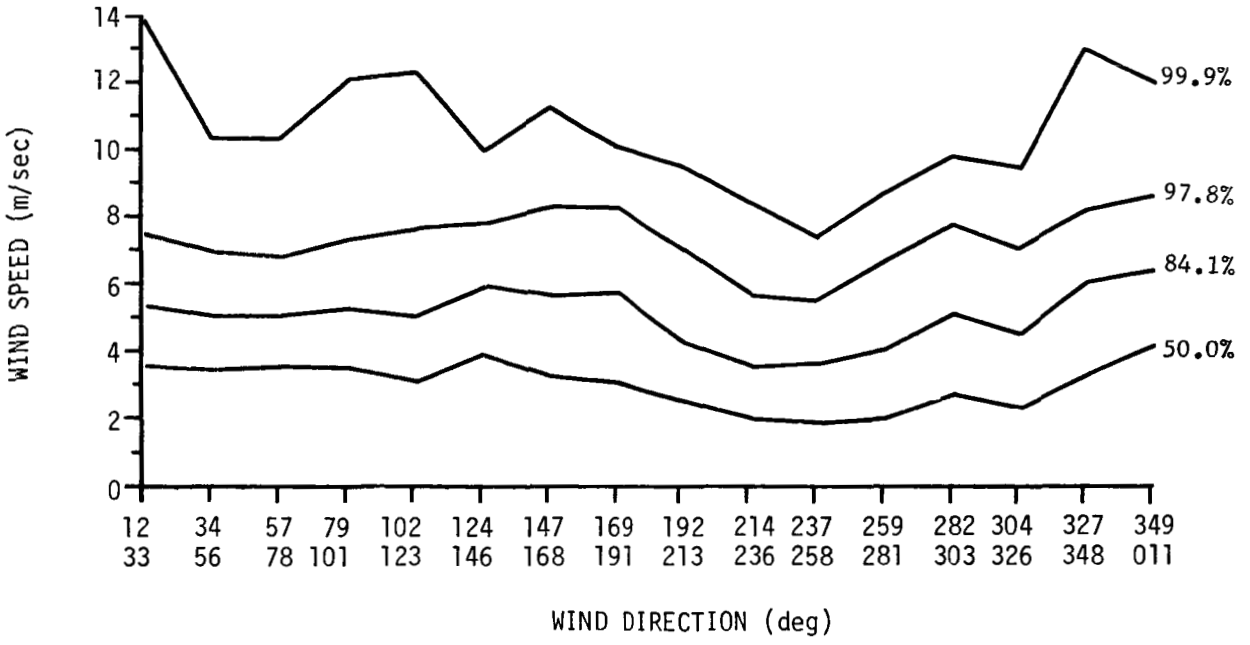

Figure 43. Annual percentile distribution of 10-min average wind speed data as a function of wind direction for the 3-m level.

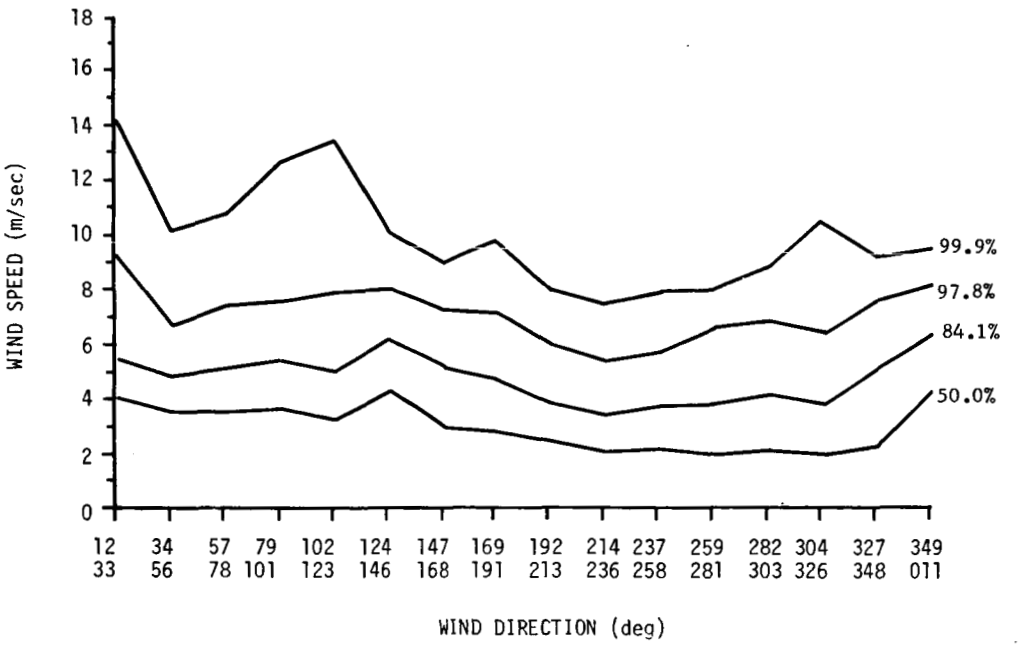

Figure 44. Summer (Apr.-Sep.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 3-m level.

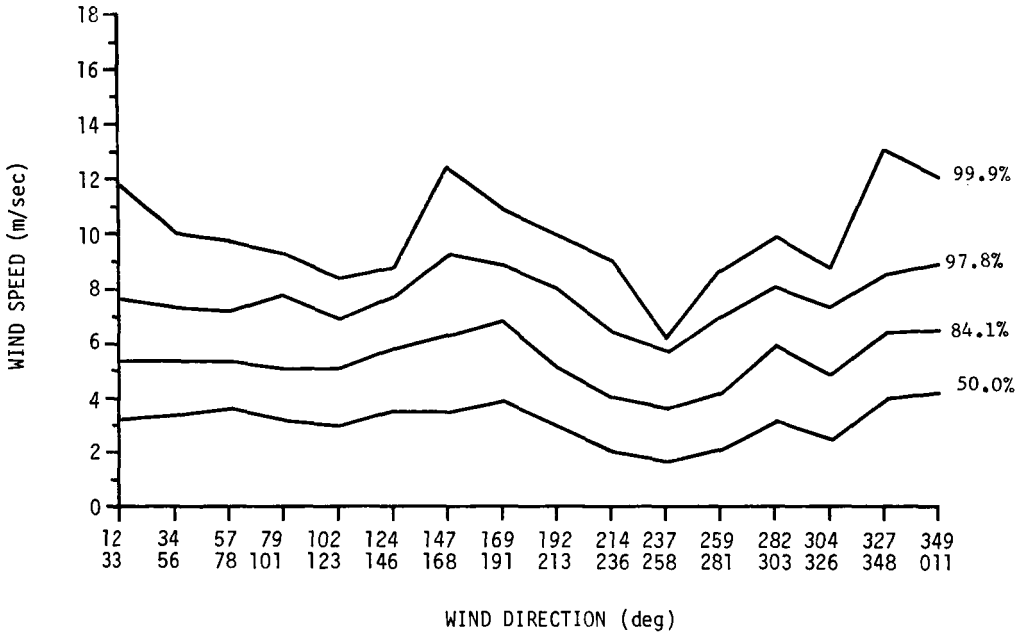

Figure 45. Winter (Oct.-Mar.) percentile distribution of 10-min average wind speed data as a function of wind direction for the 3-m level.

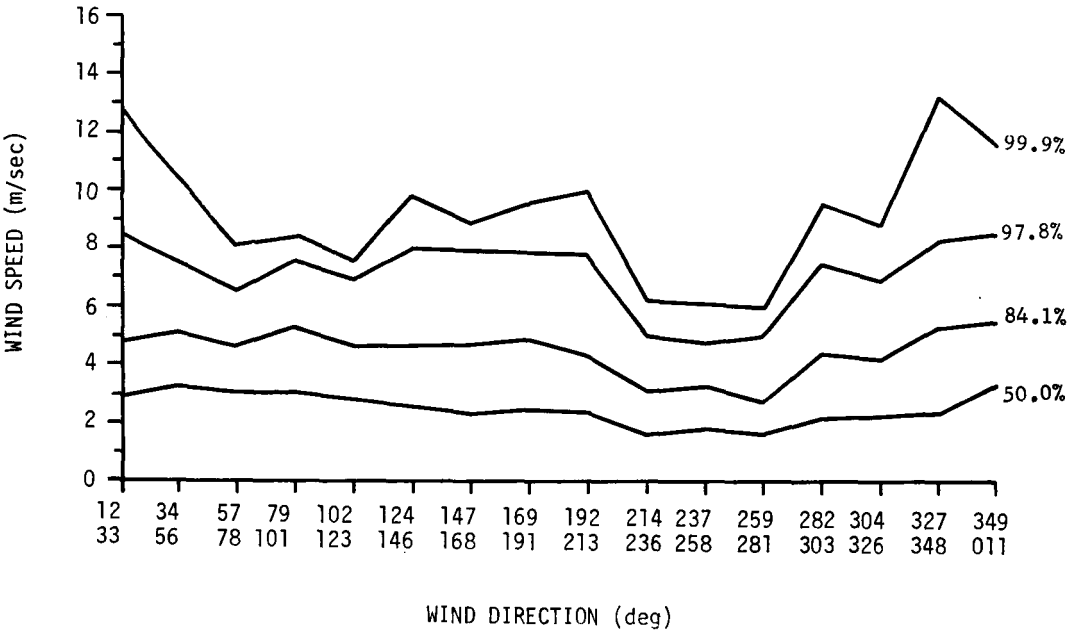

Figure 46. Morning (0500-0900 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 3-m level.

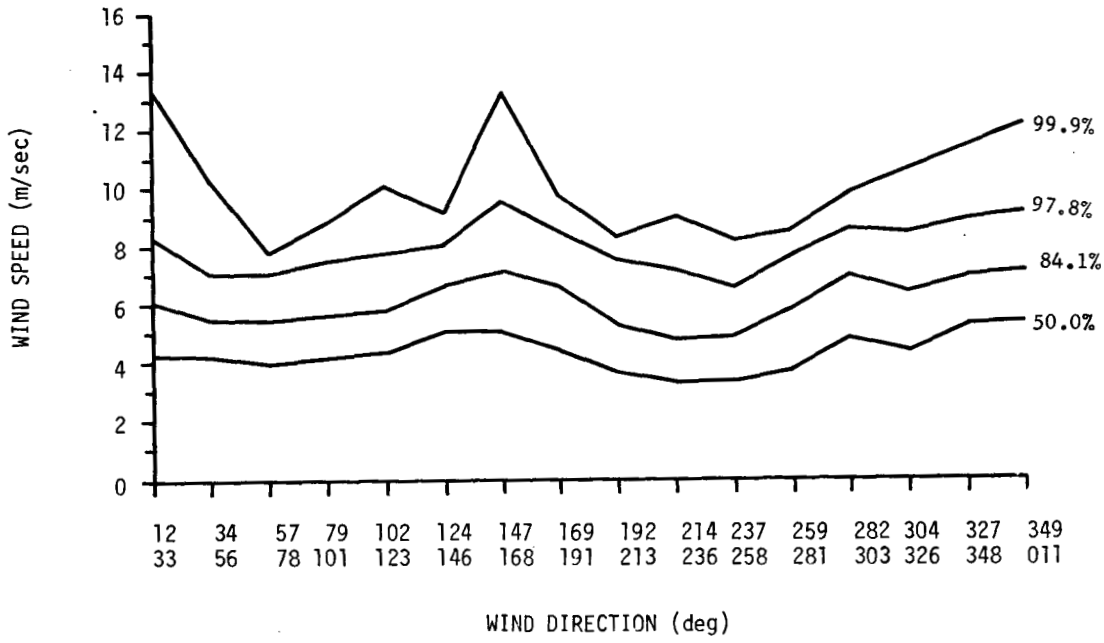

Figure 47. Daytime (1000-1600 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 3-m level.

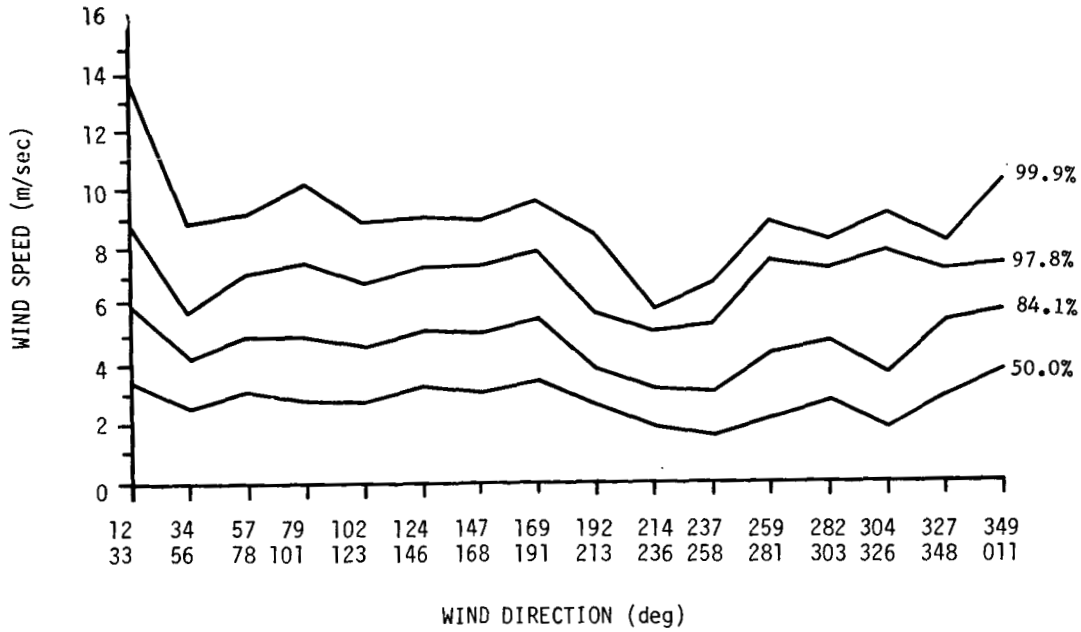

Figure 48. Evening (1700-2100 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 3-m level.

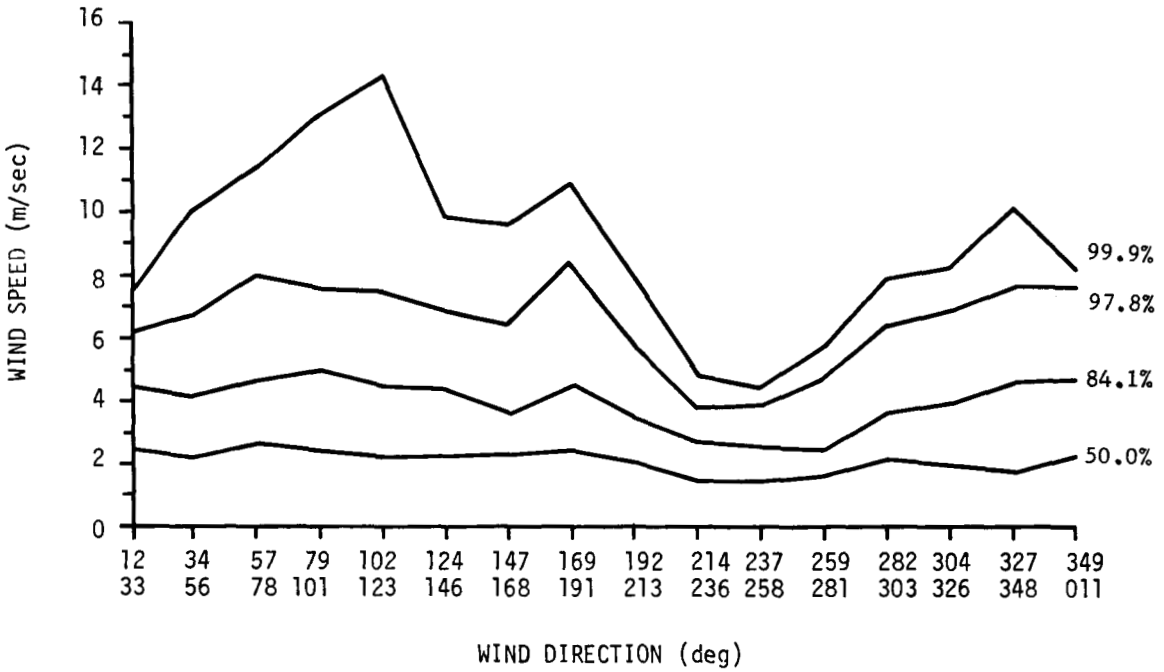

Figure 49. Nighttime (2200-0400 EST) percentile distribution of 10-min average wind speed data as a function of wind direction for the 3-m level.

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STATISTICAL DATA FROM NASA'S 150-m WIND TOWER AT KENNEDY SPACE CENTER, FLORIDA

By Kelly Hill

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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