A Weather Pattern Climatology of the Great Plains and the Related Wind Regime

W. R. Barchet

November 1982

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Richland, Washington 99352

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SUMMARY

The meteorology of the Great Plains can be described as a constant progression of air masses, fronts and cyclonic storm systems. Each of these meteorological conditions can be characterized by identifiable isobaric and related weather parameter patterns. Nine such patterns have been defined to type the weather patterns in the Great Plains.

Time series of weather pattern types were produced for 62 stations on the Great Plains. Statistical analyses of these time series produced annual and seasonal frequencies of occurrence of the weather pattern types. Maps of the annual and seasonal frequency of occurrence of weather pattern type are presented for the Great Plains. Persistence and alternation frequencies match what is expected for traveling temperate latitude cyclones, anticyclones and fronts.

The wind regime for stations at which the anemometer height and location was constant (and known) for a minimum of three consecutive years was stratified by weather pattern type. Statistical analyses were made to show the response of the wind to the large-scale distribution of air pressure associated with a weather pattern type. The response of the wind to the weather pattern is a site-specific result of the interaction of the large-scale meteorology with local terrain, surface roughness and atmospheric stability. Mean wind speed discriminates between pairs of weather pattern types with better than 75% confidence for more than two-thirds of the possible pairs of weather pattern types.

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INTRODUCTION

Measurement of the wind resource at a site is the only approach by which a wind energy planner can make a reliable estimate of the energy production potential of the site. Such measurement programs will, in general, gather data over a period of one to three years. In some regions, where the annual variability of the wind resource is high, an even longer measurement program is needed to make a reliable estimate of the wind resource. This report is the first of a series of reports that addresses the problem of evaluating how well a particular measurement period represents the long-term climatology of wind resource.

The wind resource at a site is the result of the interaction between large-scale weather systems and the physical characteristics of the site. The large-scale weather systems that affect the site set up the pressure gradients that drive the winds. However, the winds also react to features of the terrain, the roughness of the surface and the stability of the atmosphere to produce the wind regime experienced at that site. Measurement of the wind regime records the consequences of the interaction between the large-scale weather systems that affect the site and the local features of the site.

How representative the measurement period is of the long-term climatology will depend on the frequency of occurrence of various weather systems at the site within the period of observation. This report will focus on the climatology of nine distinct weather patterns in the Great Plains. A second report will deal with the problem of adjusting the measured resource to represent the long-term weather pattern climatology. A third report will present a climatology of weather pattern types for the conterminous United States.

The Great Plains was chosen as the study area because of the excellent wind resource over this area of the United States. Furthermore, the large north-south extent of the region, as shown in Figure 1, and the limited variety of topographic influences on the weather patterns make this an excellent region for testing the utility of weather pattern climatology for adjusting the results of short observation periods to the long-term climatology.

FIGURE 1. Weather Pattern Types Associated With Synoptic Weather Features

Weather patterns over the Great Plains were defined in relation to a standard model of a large-scale weather system positioned over the Great Plains. Figure 1 shows a typical weather system over the Great Plains on which the nine weather pattern types are identified. These patterns are based to a great extent on the distribution of sea-level pressure (isobar patterns) about the weather system. Weather pattern types are related to the various air masses and frontal systems that typically are present in weather systems affecting the Great Plains. Table 1 briefly defines the weather pattern types by their pressure pattern signature and by other factors that help to uniquely identify the pattern. These definitions are very sketchy. Considerable experience in synoptic meteorology is needed to consistently type weather patterns.

TABLE 1. Synoptic Classes for the Great Plains States

<u>Code</u>	<u>Meteorological Situation</u>
1	<p>Within the warm sector:</p> <ul style="list-style-type: none"> - cyclonic curvature of isobars - component of wind from south - high humidity - cumuloform clouds - some areas of precipitation - pressure falling
2	<p>Ahead of warm front:</p> <ul style="list-style-type: none"> - cyclonic curvature of isobars - component of winds from east - high humidity - stratoform clouds - continuous precipitation - pressure falling slowly
3	<p>Behind the cold front:</p> <ul style="list-style-type: none"> - cyclonic curvature of isobars - component of wind from west - intermediate humidity - scattered cumuloform clouds - shower-type precipitation - pressure rising
4	<p>To the east of continental high:</p> <ul style="list-style-type: none"> - anticyclonic curvature of isobars - component of wind from north - low humidity - few clouds - essentially no precipitation - pressure steady or rising slowly
5	<p>To the west of continental high</p> <ul style="list-style-type: none"> - anticyclonic curvature to isobars - component of wind from the south - low humidity - few clouds - essentially no precipitation - pressure steady or rising slowly

TABLE 1. (Cont.)

<u>Code</u>	<u>Meteorological Situation</u>
6	Under the influence of subtropical (maritime) high: <ul style="list-style-type: none"> - anticyclonic curvature of isobars - component of wind from south - intermediate to high humidity - few to intermediate clouds - some showers especially in afternoon - pressure steady
7	In vicinity of stationary front: <ul style="list-style-type: none"> - indeterminate curvature of isobars - light winds - intermediate humidity - variable cloudiness - few areas of precipitation - pressure steady
8	In vicinity of occluded front or west of low center: <ul style="list-style-type: none"> - cyclonic or indeterminate curvature of isobars - component of winds from north - high humidity - considerable clouds - considerable precipitation - pressure rising slowly
9	Indeterminate

WEATHER PATTERN TIME SERIES

Large-scale weather systems are seldom stationary. They move into, across, and away from the study region in a constant progression of air masses, fronts and cyclonic storm systems. As a result, the weather pattern at a particular location changes with time. The analysis of weather pattern climatology begins with the production of a time series of weather pattern types at sites located throughout the region.

DATA ANALYSIS

Data for this analysis were in the form of surface weather maps produced twice daily for midnight (0600 GMT) and noon (1800 GMT) Central Standard Time by the National Weather Service and archived at the National Climatic Center. In this study, 7300 weather maps for the period January 1, 1955, through December 31, 1964, were analyzed for 62 stations on the Great Plains. Table 2 lists the stations for which a time series of weather pattern type was produced while Figure 2 shows the location of these stations on the Great Plains.

Although the pressure pattern served as the principal indicator of weather pattern type, it was often necessary to examine secondary features such as the wind direction, cloud cover, humidity, and upper-air pressure patterns to resolve the type. Under some circumstances, no definite type could be unambiguously assigned to the weather pattern. In such cases, Type 9, called "indeterminate", was assigned.

There were some days for which either or both of the maps were "missing" from the archive. Such occurrences were also flagged as a special type. Most missing data occurred sporadically in one-day periods. However, two longer continuous periods of missing weather maps were found: 5 days ending September 17, 1963, and 16 days ending December 31, 1957. Missing data amounted to 1.2% of all observations.

The time series of weather pattern type were analyzed for 1) the frequency of occurrence of weather pattern type by month, year and period,

TABLE 2. List of 62 Stations With Numbers Corresponding to the Numbers in Figure 2, WBAN Station Numbers and Latitude and Longitude

Number	Station Name	WBAN	Latitude	Longitude
A1	Kalispell, MT	24146	N 48 18	W 114 16
A2	Great Falls, MT	24143	N 47 29	W 111 22
A3	Glasgow, MT	94008	N 48 13	W 106 37
A4	Williston/WBO, ND	24014	N 48 09	W 103 35
A5	Minot, ND	24013	N 48 16	W 101 17
A6	International Falls, MN	14918	N 48 34	W 93 23
B1	Helena, MT	24144	N 46 36	W 112 00
B2	Billings, MT	24033	N 45 48	W 108 32
B3	Miles City, MT	24037	N 46 26	W 105 52
B4	Bismarck, ND	24011	N 46 46	W 100 45
B5	Fargo, ND	14914	N 46 54	W 96 48
B6	Alexandria, MN	14910	N 45 52	W 95 23
B7	Duluth, MN	14913	N 46 50	W 92 11
C1	Sheridan, WY	24029	N 44 46	W 106 58
C2	Rapid City, SD	24090	N 44 03	W 103 04
C3	Pierre, SD	24025	N 44 23	W 100 17
C4	Aberdeen, SD	14929	N 45 27	W 98 26
C5	Sioux Falls, SD	14944	N 43 34	W 96 44
C6	Redwood Falls, MN	14992	N 44 33	W 95 05
C7	Minneapolis, MN	14922	N 44 53	W 93 13
D1	Lander, WY	24021	N 42 49	W 108 44
D2	Casper, WY	24089	N 42 55	W 106 28
D3	Sioux City, IA	14943	N 42 24	W 96 23
D4	Mason City, IA	14940	N 43 09	W 93 20
D5	Dubuque, IA	94908	N 42 24	W 90 42
E1	Rock Springs, WY	24027	N 41 36	W 109 04
E2	Cheyenne, WY	24018	N 41 09	W 104 49
E3	Scottsbluff, NE	24028	N 41 52	W 103 36
E4	North Platte, NE	24023	N 41 08	W 100 41
E5	Grand Island, NE	14935	N 40 58	W 98 19
E6	Omaha, NE	14942	N 41 18	W 95 54
E7	Des Moines, IA	14933	N 41 32	W 93 39
E8	Burlington, IA	14931	N 40 47	W 91 07

TABLE 2. (Cont.)

Number	Station Name	WBAN	Latitude	Longitude
F1	Denver, CO	23062	N 39 45	W 104 52
F2	Akron, CO	24015	N 40 10	W 103 13
F3	Goodland, KS	23065	N 39 22	W 101 42
F4	Hill City, KS	93990	N 39 23	W 99 50
F5	Russell, KS	93997	N 38 52	W 98 49
F6	Concordia, KS	13984	N 39 33	W 97 39
F7	Topeka, KS	13996	N 39 04	W 95 38
G1	Colorado Springs, CO	93037	N 38 49	W 104 43
G2	Pueblo, CO	93058	N 38 17	W 104 31
G3	Trinidad, CO	23070	N 37 15	W 104 20
G4	Dodge City, KS	13985	N 37 46	W 99 58
G5	Wichita, KS	13998	N 37 38	W 97 16
G6	Emporia, KS	13989	N 38 20	W 96 12
G7	Chanute, KS	13981	N 37 40	W 95 29
H1	Raton/Crews, NM	23052	N 36 45	W 104 30
H2	Enid, OK	13909	N 36 21	W 97 55
H3	Oklahoma City, OK	13967	N 35 24	W 97 36
H4	Tulsa, OK	13968	N 36 12	W 95 54
I1	Las Vegas, NM	23054	N 35 39	W 105 09
I2	Tucumcari, NM	23048	N 35 11	W 103 36
I3	Amarillo, TX	23047	N 35 14	W 101 42
I4	Altus, OK	13902	N 34 40	W 99 16
I5	Wichita Falls, TX	13966	N 33 58	W 98 29
I6	Ardmore, OK	13965	N 34 18	W 97 01
I7	Sherman, TX	13923	N 33 43	W 96 40
J1	Carlsbad, NM	93033	N 32 20	W 104 16
J2	Midland, TX	23023	N 31 56	W 102 12
J3	Abilene, TX	13962	N 32 26	W 99 41
J4	Dallas/Love, TX	13960	N 32 51	W 96 51

FIGURE 2. Great Plains States and Station Locations. Station numbers correspond to the numbers given in Table 2.

2) the interannual variability of the frequency of occurrence, 3) the persistence of weather pattern type, and 4) the alteration from one type to another.

RESULTS

The statistics on the frequency of occurrence of the various weather pattern types were determined for each of the stations over the ten-year period of record. The frequency of occurrence is calculated from the number of observations of a given weather pattern type divided by the total number of nonmissing observations. The frequency of occurrence is the result of the number of times the weather pattern type affects a location, the speed of its movement, and the horizontal extent of the weather pattern type.

Some of these weather pattern types cover a small area (Types 1, 2, 3, and 8) and move relatively quickly. The residence time of such types at a particular location is short and the frequency of occurrence is usually low. Types 4, 5 and 6 are associated with high-pressure systems that cover a large area and move slower than the frontal systems; thus, these types have longer residence times and higher frequencies of occurrence. Type 7 covers a small area but moves very slowly (as the term "stationary front" implies), and thus may show a higher frequency of occurrence than Types 2, 3 or 8.

The distribution of the annual frequency of occurrence of the weather pattern types over the Great Plains is shown in Figure 3. The isolines represent lines of constant frequency of occurrence. At any point, the sum of frequencies from all nine weather pattern types totals to nearly 100%.

The monthly variability of weather pattern frequency of occurrence is shown in Figures 4 and 5 for two stations selected to show the dependence of this variability on location. The monthly mean frequency of occurrence is determined by summing the occurrence of each weather pattern type over all days in the month for all years in the period and dividing the sum by the number of nonmissing observations for the month over all years in the period.

FIGURE 3. Distribution of Weather Pattern Annual Frequency of Occurrence Over the Great Plains for the Period January 1, 1955 to December 31, 1964. Numbers give the percent frequency of occurrence.

FIGURE 4. Monthly Distribution of Weather Pattern Frequency of Occurrence for Rapid City, South Dakota

The northern High Plains, north of Kansas, is characterized by the seasonal pattern shown for Rapid City, South Dakota, in Figure 4. In this region, the cold core, continental anticyclone (high pressure system) dominates the weather pattern types. The sum of Types 4 and 5, both related to the continental high, is nearly 50%. Furthermore, the northerly location of this area results in the nearly complete absence of the subtropical anticyclone, weather pattern Type 6.

The southern High Plains, Kansas southward, is characterized by the seasonal variations shown for Oklahoma City, Oklahoma, in Figure 5. This area experiences a very large seasonal variation in the occurrence of the major high pressure systems. In winter, the cold, continental polar high (Types 4

FIGURE 5. Monthly Distribution of Weather Pattern Frequency of Occurrence for Oklahoma City, Oklahoma

and 5) dominates the weather pattern frequency (>40%) while in summer, the warm, humid, subtropical high (Type 6) briefly becomes the dominant weather pattern type. As can be seen in Figure 3, the occurrence of Type 6 diminishes rapidly with distance inland from the Gulf Coast.

The seasonal patterns of weather pattern frequency of occurrence over the Great Plains are shown in Figure 6 for winter (December, January, February), Figure 7 for spring (March, April, May), Figure 8 for summer (June, July, August), and Figure 9 for autumn (September, October, November). The seasonal frequencies of occurrence were calculated by averaging the appropriate monthly frequencies.

FIGURE 6. Distribution of Weather Pattern Frequency of Occurrence Over the Great Plains in Winter (December, January, February)

FIGURE 7. Distribution of Weather Pattern Frequency of Occurrence Over the Great Plains in Spring (March, April, May)

FIGURE 8. Distribution of Weather Pattern Frequency of Occurrence Over the Great Plains in Summer (June, July, August)

FIGURE 9. Distribution of Weather Pattern Frequency of Occurrence Over the Great Plains in Autumn (September, October, November)

Winter is dominated by the continental polar high, Types 4 and 5. The sluggish stationary front, Type 7, shows a strong influence in the Montana plains. Type 6, the subtropical high, is essentially absent except rarely in the extreme southern plains of Texas. Cold fronts sweep through the plains quickly and are present rather uniformly over all the plains.

In spring, the most noticeable change from winter is in the pattern for Type 4. The disappearance of the anticyclone over the Rocky Mountains and fewer continental polar air masses pushing southward along the Rockies produce a markedly different distribution of frequency isolines and much lower frequencies of occurrence for Type 4. The springtime influx of subtropical air is noted by the strong gradient in Type 6 over central Texas. Although the frequency of Types 4 and 5 remains high, cyclonic storm activity raises the frequency of frontal patterns (Types 1, 3 and 8). The eastward bulge of isolines over Kansas is the transition to the summer pattern and marks the boundary between subtropical air masses and continental polar air masses.

Summer contrasts sharply with the winter patterns. The difference between the northern plains and the southern plains is clearly seen in the orientation of the gradients. For Types 2, 3, and 5, the gradients over the northern plains remain weakly east-west whereas the southern plains have mainly north-south gradients in the frequency of occurrence. But, for Types 1 and 8, north-south gradients are associated with the northern plains while the east-west gradient in frequency is found in the southern plains. The warm sector, Type 1, attains its maximum frequency and greatest extent of influence over the southern High Plains. Type 6 is also at its highest frequency and northward extent with a strong gradient through the transition region in the Central Plains. This transition region also shows in the pattern of Type 7, which has its maximum along the southern edge of the transition region. A consequence of the presence of Type 6 is the nearly complete reversal of the gradients in frequency of occurrence of Type 5. The patterns of isolines for Types 3 and 8 indicate that cyclonic storms travel mostly across the far northern limit of the region. Type 9 attains its maximum frequency over southwestern Texas as a thermal low over the high inland desert of northern Mexico.

creates a pressure pattern in this area that does not fit the model of Figure 1.

Autumn begins the transition back to the winter pattern. East-west gradients are again forming in Types 4 and 5 as these weather pattern types regain dominance and in Type 7 as the frontal systems become more frequent in the northern plains. Type 6 begins to recede and weaken as it is replaced by Type 4.

Statistics on the persistence of weather pattern type at selected stations were produced for a few locations. Persistence was defined as the number of consecutive observations of the same weather pattern type. Table 3 gives the persistence of weather pattern type at Rapid City. Part A of the table considers persistence between every consecutive observation (map). This is called "composite" because day and night are combined. Since there are two maps per day (midnight and noon), run duration is measured as the number of

TABLE 3. Persistence of Weather Pattern Types at Rapid City, South Dakota as the Percentage of All Runs for Type With Indicated Duration of Consecutive Observations

Part A: Persistence for all observations; interval between observations is 12 hours

RUN DURATION	WEATHER PATTERN TYPE								
	1	2	3	4	5	6	7	8	9
1	67.8	89.4	76.1	59.9	58.6	92.9	63.7	70.4	74.0
2	20.7	10.1	17.5	20.6	20.3	7.1	20.5	18.7	16.4
3	6.4	0.5	5.5	10.1	9.6	0.0	9.1	5.8	6.5
4	3.3	0.0	0.3	4.8	5.8	0.0	2.8	2.7	1.5
5	0.8	0.0	0.3	2.2	2.5	0.0	2.5	1.9	0.9
6	0.6	0.0	0.3	1.0	0.8	0.0	0.4	0.4	0.3
7	0.0	0.0	0.0	0.8	0.9	0.0	0.4	0.0	0.0
8	0.5	0.0	0.0	0.2	0.7	0.0	0.1	0.0	0.0
9	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.3
10	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
11	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
RUNS	658	217	653	858	856	14	673	257	323

TABLE 3 (continued)

Part B: Midnight to midnight persistence; interval between observations is 24 hours

RUN DURATION	WEATHER PATTERN TYPE								
	1	2	3	4	5	6	7	8	9
1	77.3	94.5	84.1	68.4	62.4	75.0	69.8	79.1	76.4
2	16.5	5.5	13.2	21.5	24.5	25.0	17.8	14.6	15.4
3	4.6	0.0	2.7	6.1	7.8	0.0	8.5	5.1	5.5
4	1.1	0.0	0.0	2.0	3.2	0.0	2.0	1.3	0.5
5	0.3	0.0	0.0	1.2	1.1	0.0	1.1	0.0	2.2
6	0.0	0.0	0.0	0.4	0.8	0.0	0.3	0.0	0.0
7	0.3	0.0	0.0	0.2	0.2	0.0	0.6	0.0	0.0
8	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
RUNS	370	110	365	493	527	8	354	158	182

Part C: Noon to noon persistence; interval between observations is 24 hours

RUN DURATION	WEATHER PATTERN TYPE								
	1	2	3	4	5	6	7	8	9
1	75.5	97.5	85.9	67.0	66.3	100.0	69.3	74.3	75.8
2	18.0	1.7	10.5	21.6	22.5	0.0	19.6	22.1	18.5
3	3.7	0.0	2.5	7.3	6.0	0.0	7.5	2.2	2.5
4	2.1	0.8	1.1	2.7	3.6	0.0	2.0	1.5	3.2
5	0.3	0.0	0.0	0.8	1.0	0.0	1.0	0.0	0.0
6	0.5	0.0	0.0	0.2	0.4	0.0	0.3	0.0	0.0
7	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.0
8	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
RUNS	383	120	362	522	502	5	398	136	157

TABLE 3 (continued)

PART D: Midnight to noon persistence; interval between observations is 24 hours

RUN DURATION	WEATHER PATTERN TYPE								
	1	2	3	4	5	6	7	8	9
1	66.8	73.3	70.0	62.0	59.1	66.7	68.0	63.6	65.2
2	21.1	22.9	18.5	24.2	24.3	11.1	22.0	19.6	21.9
3	8.3	2.9	7.4	8.6	8.5	22.2	7.1	10.5	8.6
4	2.6	1.0	2.9	3.3	5.3	0.0	1.9	4.2	2.7
5	0.3	0.0	1.2	1.0	1.4	0.0	0.6	1.4	1.1
6	0.0	0.0	0.0	0.3	0.8	0.0	0.0	0.7	0.5
7	0.6	0.0	0.0	0.8	0.4	0.0	0.3	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
RUNS	313	105	340	397	494	9	322	143	187

Part E: Noon to midnight persistence; interval between observations is 24 hours

RUN DURATION	WEATHER PATTERN TYPE								
	1	2	3	4	5	6	7	8	9
1	61.4	68.8	62.6	61.4	60.8	80.0	62.7	70.2	68.4
2	24.1	20.5	22.4	22.3	23.2	20.0	20.5	15.8	17.6
3	7.5	3.6	6.4	10.8	8.6	0.0	9.1	9.6	10.3
4	4.3	4.5	4.8	3.3	3.9	0.0	3.4	0.0	0.7
5	1.7	1.8	1.3	0.9	1.7	0.0	2.3	2.6	2.2
6	0.6	0.0	0.6	0.7	1.1	0.0	1.4	0.0	0.7
7	0.3	0.9	1.3	0.0	0.3	0.0	0.3	0.0	0.0
8	0.0	0.0	0.6	0.2	0.0	0.0	0.0	0.9	0.0
9	0.0	0.0	0.0	0.2	0.6	0.0	0.3	0.9	0.0
17	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
RUNS	345	112	313	461	362	5	351	114	136

consecutive observation increments of 12 hours. A duration of three observations is thus equivalent to 36 hours. The values represent the probability that having had a run of the indicated duration of weather pattern, the next map (or next similar map time) will be some other weather pattern. Diurnal variations in the pressure patterns frequently result in different classifications from day to night although no substantial change in the synoptic situation has occurred. The effect of these diurnal changes can be seen at Rapid City in parts B and C of Table 3. For these parts of the persistence table, one observation is equivalent to 24 hours. Persistence in real time is much longer when the diurnal variations are "filtered" out. Weather pattern types associated with larger-scale features, e.g., Types 1, 4, 5 and 6 (for more southerly locations) do have significant fractions of runs with durations of several days. The slow-moving and slow-changing stationary front, Type 7, also shows significant persistence.

The Rapid City persistence pattern shown in Table 3 is representative of much of the Great Plains. Only Type 6 shows a significant change from north (where Type 6 rarely occurs) to south (where Type 6 dominates the summer season). However, the southern Great Plains show a higher percentage of long-run durations than do the northern plains. These longer runs are associated with Types 1, 5, 6 and 7. Stations in the northern Great Plains show a tendency for longer runs with Type 4 than with Type 5, whereas in the southern plains, Type 5 usually exhibits the longer durations.

The alternation from one weather pattern type to another was also examined for several stations. Table 4 gives the alternation as the percentage of runs of Type I that changed to Type J. Parts A and B of Table 4 give the midnight-to-midnight and noon-to-noon alternation. These show essentially similar patterns. Parts C and D give the midnight-to-noon and noon-to-midnight alternation. These measure the diurnal fluctuation in weather pattern type. The values represent the probability that when a run of Type I ends, the next type will be J. The last line in each of these parts gives the number of runs for that type. The sum of the runs given in Parts C and D for a weather pattern type equals the total number of runs for that type. The alternation frequencies follow the sequence expected from the synoptic model of Figure 1.

The only significant regional variation is the frequency of alternation to Type 6, which shows the strong north to south increase in frequency of occurrence of this weather pattern type.

TABLE 4. Frequency of Alternation From Weather Pattern Type I (Row) to Type J (Column) at Rapid City, South Dakota, as the Percentage of Runs of Type I that Change to Type J

Part A: Midnight to midnight alternation

TYPE I	TYPE J								
	1	2	3	4	5	6	7	8	9
1	0.0	2.7	34.3	23.0	10.8	0.3	19.2	4.3	4.9
2	11.8	0.0	22.7	17.3	19.1	0.0	19.1	4.5	4.5
3	13.2	5.5	0.0	30.1	23.0	0.5	17.0	5.8	4.1
4	15.6	4.9	8.1	0.0	46.5	0.4	10.5	4.1	9.3
5	25.8	6.3	9.7	19.4	0.0	0.0	18.6	8.3	11.2
6	12.5	12.5	12.5	12.5	0.0	0.0	12.5	12.5	25.0
7	18.1	3.7	19.2	19.5	20.1	0.3	0.0	11.6	6.8
8	8.2	1.3	12.7	31.6	22.8	0.6	14.6	0.0	7.6
9	8.8	3.3	16.5	29.1	23.1	0.0	12.6	4.9	0.0
RUNS	370	110	365	493	527	8	354	158	182

Part B: Noon to noon alternation

TYPE I	TYPE J								
	1	2	3	4	5	6	7	8	9
1	0.0	3.7	29.5	25.3	9.7	0.0	22.2	5.0	3.7
2	15.0	0.0	26.7	20.0	11.7	0.0	15.0	5.0	6.7
3	9.1	3.0	0.0	29.6	26.0	0.6	21.5	4.1	5.2
4	20.1	6.9	6.5	0.0	38.9	0.4	12.8	4.0	9.4
5	23.9	6.2	13.1	22.3	0.0	0.0	20.3	5.6	8.0
6	0.0	0.0	20.0	0.0	20.0	0.0	60.0	0.0	0.0
8	8.1	2.9	7.4	31.6	22.8	0.0	19.1	0.0	6.6
9	12.7	3.8	10.2	31.8	21.7	0.0	10.8	7.6	0.0
RUNS	383	120	362	522	502	5	398	136	157

TABLE 4 (continued)

Part C: Midnight to noon alternation

TYPE I	1	2	3	4	TYPE J 5	6	7	8	9
1	0.0	3.5	35.1	17.9	8.3	0.0	23.3	5.4	5.8
2	22.9	0.0	30.5	13.3	8.6	0.0	11.4	6.7	5.7
3	7.6	2.9	0.0	39.7	20.9	0.0	19.4	5.3	3.2
4	11.8	4.3	9.6	0.0	49.6	0.5	12.8	3.8	7.3
5	23.5	9.5	6.5	19.8	0.0	0.2	24.1	6.3	9.5
6	22.2	0.0	0.0	33.3	11.1	0.0	11.1	11.1	11.1
7	28.3	5.0	22.4	18.0	13.0	0.0	0.0	5.9	6.5
8	7.0	1.4	20.3	26.6	18.2	0.7	15.4	0.0	9.8
9	14.4	5.9	10.7	23.5	21.9	0.0	16.0	5.3	0.0
RUNS	313	105	340	397	494	9	322	143	187

Part D: Noon to midnight alternation

TYPE I	1	2	3	4	TYPE J 5	6	7	8	9
1	0.0	1.7	35.9	18.3	11.0	0.0	21.4	4.9	6.7
2	31.3	0.0	25.0	4.5	13.4	0.0	12.5	8.9	4.5
3	8.3	2.9	0.0	34.5	21.1	0.6	20.1	6.4	6.1
4	13.9	5.0	9.1	0.0	46.0	0.7	10.6	3.9	10.8
5	18.5	10.2	6.4	27.9	0.0	0.8	18.0	6.1	11.9
6	20.0	0.0	0.0	20.0	0.0	0.0	20.0	20.0	0.0
7	23.4	5.4	16.8	17.9	18.8	0.3	0.0	10.8	6.6
8	18.4	1.8	14.9	25.4	16.7	0.0	10.5	0.0	11.4
9	13.2	5.1	16.2	27.2	15.4	0.7	12.5	9.6	0.0
RUNS	345	112	313	461	362	5	351	114	136

WIND REGIME CLIMATOLOGY

Every location offers a unique combination of terrain, surface roughness and other obstacles to air flow that results in a very site-specific response of the wind regime to the large-scale meteorology of a weather pattern type. This means that the statistics on the wind regime are site-specific and can not be applied with confidence to other sites. The analyses described below show the general character of the wind regime associated with each weather pattern type. However, they are not meant to describe the wind resource.

DATA ANALYSIS

Stations were selected for an analysis of wind statistics if the period of record with constant anemometer height and location exceeded three years. Only 28 stations (37 periods of record) were analyzed in detail. These stations are listed in Table 5 along with the period of record and the anemometer height. For 10 stations, 2 periods at different anemometer heights were analyzed to examine the vertical shear of the long-term wind speed.

Hourly surface weather observations were available in the National Climatic Center TD1440 data set for the 28 stations. Wind data at map time and for the 12-hour period centered on the map time were extracted from the TD1440 surface observations. The wind data and the weather pattern type data were combined into a single data set for each station.

The wind regime for each period of record was stratified according to the weather pattern type and analyzed for monthly, yearly and periodic means, frequency distributions and variability. Tables 6 through 12 summarize various wind statistics for the stations and periods listed in Table 5. All speeds are in m/s. Tables 8 and 9 give the mean U and V components to the wind. Winds from the east have $U > 0$; winds from the north have $V > 0$.

TABLE 5. Period of Record of the Stations for Which
Statistics of the Wind Resource Were Determined

<u>WBAN</u>	<u>Station</u>	<u>State</u>	<u>Start Period</u>	<u>End Period</u>	<u>Anemometer Height (ft)</u>
93037	Colorado Springs	CO	580220	641231	22
23062	Denver/Stapleton	CO	550101	600707	72
23062	Denver/Stapleton	CO	600708	641231	20
93058	Pueblo	CO	550101	620318	34
14933	Des Moines	IA	550617	610629	69
14933	Des Moines	IA	610630	641231	20
14940	Mason City	IA	550101	641231	20
23065	Goodland	KS	550101	640322	31
13996	Topeka	KS	550101	640809	72
14922	Minneapolis	MN	580918	641231	21
24143	Great Falls	MT	550101	590202	75
24143	Great Falls	MT	590202	641231	22
24144	Helena	MT	550101	610919	44
24144	Helena	MT	610920	641231	20
14935	Grand Island	NE	550101	611201	47
14935	Grand Island	NE	611202	641231	20
24023	North Platte	NE	550101	640811	32
24028	Scottsbluff	NE	550101	640801	50
24011	Bismarck	ND	550101	611016	43
23052	Raton/Crews	NM	551101	641231	22
23048	Tucumcari	NM	550101	590917	32
23048	Tucumcari	NM	590918	641231	22
13902	Altus	OK	560803	641231	12
13967	Oklahoma City	OK	550101	641231	55
13968	Tulsa	OK	560224	601227	39
13968	Tulsa	OK	601228	641231	23
24090	Rapid City	SD	550101	641231	32
14944	Sioux Falls	SD	560418	611124	55
23047	Amarillo	TX	561028	610502	33
23047	Amarillo	TX	610503	641231	23
13960	Dallas/Love	TX	580429	641231	20
23023	Midland	TX	550101	591203	35
23023	Midland	TX	591204	641231	22
24089	Casper	WY	580130	640811	29
24027	Rock Springs	WY	550101	600726	50
24027	Rock Springs	WY	600727	641231	20
24029	Sheridan	WY	580610	640902	42

Dates are given as YYMMDD, YY=year, MM=month, DD=day.

TABLE 6. Mean Wind Speed (m/s) and Its Standard Deviation (m/s)
at Map Time by Weather Pattern Type

STATION	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---	--- 6 ---	--- 7 ---	--- 8 ---	--- 9 ---
W1390264	4.33 2.97	4.29 2.93	4.81 2.94	3.71 2.51	3.89 2.65	3.37 2.50	4.42 2.85	5.09 2.90	4.52 3.17
W1396064	5.63 2.45	5.59 2.25	5.24 2.59	4.61 2.45	4.98 2.31	4.91 1.97	5.33 2.28	5.80 2.33	5.40 2.76
W1396764	6.39 2.51	6.15 2.82	6.28 2.89	5.46 2.30	5.62 2.22	5.59 2.01	6.05 2.36	6.96 3.00	6.15 3.03
W1396860	4.51 2.60	4.35 2.77	4.88 3.01	4.01 2.63	3.82 2.25	3.60 2.03	4.30 2.45	4.58 2.84	4.86 3.07
W1396864	5.60 2.62	5.03 2.43	5.20 2.07	4.61 2.31	4.79 2.21	4.67 1.96	4.84 2.44	5.83 2.22	5.32 2.51
W1399664	5.70 3.19	5.95 2.94	5.68 2.99	4.68 2.54	4.96 2.79	5.34 3.01	5.31 2.90	6.30 2.96	5.29 3.07
W1492264	4.73 2.65	4.97 2.53	5.20 2.77	4.10 2.32	4.05 2.32	3.79 2.27	4.65 2.40	5.11 2.61	4.79 2.79
W1493361	5.34 2.38	5.87 2.73	6.07 2.72	4.81 2.32	4.78 2.00	4.87 2.26	5.04 2.47	6.32 2.85	5.60 2.78
W1493364	4.89 2.83	3.86 2.50	4.71 2.49	4.02 2.34	4.10 2.20	3.91 1.94	4.02 2.44	5.12 2.91	4.49 2.56
W1493561	5.91 2.79	6.19 2.70	5.85 2.77	5.01 2.32	5.27 2.50	5.31 2.28	5.71 2.87	6.92 3.00	5.77 2.77
W1493564	5.59 2.72	5.48 2.59	5.19 2.46	4.60 2.56	4.84 2.33	4.44 2.59	5.32 2.93	5.76 3.26	5.29 2.83
W1494064	5.52 2.71	5.73 3.01	5.91 2.64	4.92 2.55	4.77 2.51	4.91 2.65	5.13 2.77	6.54 3.05	5.61 2.99
W1494461	4.70 2.66	5.34 2.99	5.35 2.97	4.28 2.66	4.28 2.49	4.96 2.61	4.74 2.59	5.85 3.02	5.17 3.33
W2302359	4.25 2.38	4.34 2.34	4.97 2.33	3.58 2.10	4.07 2.24	3.72 2.13	4.44 2.31	4.85 2.83	4.31 2.22
W2302364	5.05 2.52	5.04 2.79	5.37 2.75	4.65 2.49	4.69 2.36	4.50 2.26	5.40 2.65	5.71 2.60	4.88 2.46
W2304761	6.05 2.71	5.39 2.01	5.84 2.78	5.26 2.88	5.40 2.53	5.02 2.17	5.76 2.51	6.51 2.91	5.71 3.02
W2304764	6.42 2.79	4.97 2.29	6.50 3.08	5.93 2.82	6.27 2.68	5.94 2.45	6.50 2.96	8.18 3.81	6.45 3.17
W2304859	5.74 2.70	5.33 3.43	5.58 2.78	4.62 2.54	4.80 2.52	4.22 2.88	5.29 2.67	5.28 2.93	5.19 2.68
W2304864	4.64 2.79	3.23 2.42	4.61 2.74	3.58 2.41	3.85 2.59	4.18 2.48	4.47 2.88	5.31 2.78	4.42 2.92
W2305264	5.22 3.33	4.07 3.10	5.14 3.35	3.97 2.95	3.87 2.56	4.45 2.62	4.82 3.13	5.92 3.63	4.98 3.76
W2306260	5.35 2.72	5.06 2.67	5.30 2.87	5.01 2.51	4.63 2.19	5.13 2.96	5.01 2.38	5.71 2.92	5.61 3.01
W2306264	4.15 2.31	4.77 2.40	4.40 2.41	3.87 1.95	3.66 1.98	5.57 2.80	4.21 2.49	4.58 2.14	4.04 2.55
W2306564	5.50 3.00	6.14 3.01	5.58 2.95	4.56 2.41	5.25 2.66	5.27 3.04	5.49 2.85	6.29 3.23	5.14 3.09
W2401161	5.37 3.13	5.36 3.07	5.86 3.29	4.77 2.93	4.72 2.58	5.03 2.06	5.42 3.06	6.58 3.37	5.30 3.18
W2402364	4.92 2.97	4.78 3.09	5.10 3.14	4.28 2.86	4.41 2.62	4.59 2.84	4.85 3.03	6.08 3.72	4.88 3.23
W2402760	6.16 3.79	6.07 5.43	6.44 3.70	5.79 3.52	4.20 3.02	7.58 5.29	5.92 3.45	6.62 3.78	5.78 3.53
W2402764	5.66 3.06	5.80 3.10	5.47 3.25	5.07 3.20	3.97 2.94	3.70 3.90	5.48 3.20	6.29 2.95	5.00 3.34
W2402864	5.12 3.15	5.15 3.23	5.45 3.08	4.68 2.73	4.69 2.55	4.97 2.57	5.19 2.93	6.30 3.49	5.22 2.94
W2402964	3.99 3.33	4.22 3.59	4.36 3.20	3.51 2.92	2.80 2.59	0.00 0.00	3.62 2.87	4.72 3.80	3.60 3.25
W2408964	6.04 3.14	6.49 4.23	6.05 3.26	5.83 2.97	4.81 2.83	3.10 0.00	5.71 3.23	5.89 3.28	5.66 3.20
W2409064	5.23 3.41	5.08 3.63	5.59 3.37	4.73 3.15	4.30 2.78	3.69 1.62	4.97 3.14	6.30 3.60	5.09 3.27
W2414359	7.89 3.80	7.25 4.16	6.79 3.78	7.79 3.80	5.53 3.37	8.37 3.21	6.30 3.60	7.47 3.76	6.23 3.14
W2414364	5.83 3.07	5.19 2.89	5.18 2.91	5.75 3.19	4.26 2.61	0.00 0.00	4.98 3.11	6.17 3.28	5.26 3.14
W2414461	4.46 3.08	3.68 3.24	4.54 2.97	3.86 2.73	3.04 2.37	4.63 3.54	3.85 2.80	5.07 3.08	3.77 2.73
W2414464	3.82 2.70	3.08 1.35	3.95 2.50	3.68 2.50	3.04 2.02	0.00 0.00	3.59 2.68	4.33 2.82	4.16 2.79
W9303764	5.14 2.57	5.00 3.24	4.95 2.70	4.28 2.10	4.20 2.06	5.08 2.53	4.78 2.40	5.79 3.04	4.81 2.56
W9305862	4.26 3.03	4.56 3.35	4.41 3.45	3.40 2.67	3.04 2.31	3.67 2.97	4.15 2.96	5.07 3.77	4.25 3.22

TABLE 7. Average 12-Hour Mean Wind Speed (m/s) and Its Standard Deviation (m/s) for 12-Hour Period Centered on Map Time by Weather Pattern Type

STATION	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---	--- 6 ---	--- 7 ---	--- 8 ---	--- 9 ---
W1390264	4.72 1.97	4.75 1.96	4.94 2.21	4.02 1.75	4.18 1.74	4.01 1.56	4.70 1.91	5.18 2.05	4.87 2.29
W1396064	5.77 1.95	5.44 1.96	5.24 1.98	4.66 1.86	5.00 1.78	5.11 1.55	5.34 1.77	5.94 1.82	5.46 2.09
W1396764	6.51 2.03	6.32 2.11	6.26 2.31	5.49 1.90	5.69 1.77	5.89 1.56	6.11 1.85	6.70 2.31	6.28 2.41
W1396860	4.89 1.94	4.92 1.76	5.15 2.16	4.42 1.87	4.10 1.56	4.01 1.39	4.50 1.63	5.04 1.98	4.96 2.27
W1396864	5.63 2.02	5.44 1.87	5.13 1.62	4.71 1.72	4.98 1.69	4.96 1.43	5.05 1.76	5.97 1.79	5.44 1.92
W1399664	6.01 2.37	6.18 2.13	5.74 2.04	4.96 1.80	5.26 1.94	5.66 1.93	5.59 2.07	6.33 2.16	5.57 2.27
W1492264	4.90 2.04	5.26 1.94	5.27 2.02	4.33 1.75	4.35 1.69	4.29 1.60	4.91 1.87	5.29 2.06	5.04 2.22
W1493361	5.51 1.91	6.06 2.13	6.21 2.19	4.93 1.87	4.92 1.58	5.03 1.66	5.14 1.84	6.29 2.38	5.84 2.36
W1493364	5.19 2.23	4.61 1.93	4.85 1.93	4.29 1.73	4.39 1.57	4.43 1.66	4.31 1.70	5.45 2.34	4.83 1.88
W1493561	6.15 2.16	6.53 1.98	5.93 2.05	5.18 1.84	5.50 1.90	5.92 1.64	5.86 2.14	6.78 2.34	5.98 2.26
W1493564	5.65 2.08	5.51 1.99	5.31 1.85	4.83 1.95	5.00 1.77	5.06 1.74	5.34 2.00	5.93 2.49	5.51 2.33
W1494064	5.70 2.01	6.13 2.28	5.94 2.07	5.17 1.95	5.13 1.85	5.23 1.60	5.39 2.01	6.72 2.50	5.91 2.42
W1494461	5.00 1.86	5.58 2.29	5.39 2.09	4.59 1.99	4.65 1.83	5.38 1.61	4.93 1.91	6.08 2.28	5.36 2.67
W2302359	4.75 1.36	4.65 1.31	5.20 1.54	4.24 1.29	4.49 1.32	4.46 1.17	4.79 1.34	5.34 1.98	4.64 1.39
W2302364	5.34 1.64	5.29 1.59	5.48 1.80	4.84 1.56	4.97 1.55	5.05 1.37	5.58 1.68	5.71 1.83	5.12 1.69
W2304761	5.89 2.02	5.42 1.44	5.69 1.95	5.17 2.08	5.32 1.82	5.09 1.61	5.61 1.72	6.31 2.26	5.62 2.34
W2304764	6.45 1.99	5.52 2.18	6.47 2.31	5.85 2.07	6.30 1.96	6.12 1.71	6.52 2.03	7.80 2.56	6.55 2.44
W2304859	5.94 1.74	5.67 1.96	5.90 1.91	5.12 1.52	5.24 1.52	5.09 1.31	5.62 1.49	5.86 1.74	5.58 1.76
W2304864	5.13 1.57	4.06 1.46	5.01 1.68	4.41 1.49	4.57 1.53	4.80 1.35	4.98 1.71	5.54 1.81	4.79 1.85
W2305264	4.51 2.22	4.38 2.06	4.73 2.37	3.82 2.09	3.68 1.89	3.74 1.79	4.33 1.99	5.22 2.78	4.66 2.75
W2306260	5.12 1.72	5.40 1.84	5.23 1.82	4.92 1.58	4.54 1.52	4.86 1.62	4.82 1.55	5.34 2.11	5.23 1.97
W2306264	4.29 1.40	4.32 1.27	4.26 1.46	4.01 1.12	3.74 1.14	5.12 2.10	4.20 1.44	4.61 1.68	4.12 1.55
W2306564	5.88 2.13	6.44 2.33	5.91 2.20	5.13 1.79	5.56 1.95	5.76 2.28	5.70 2.03	6.56 2.63	5.65 2.38
W2401161	5.39 2.17	5.63 2.38	5.79 2.44	4.87 2.17	4.77 1.94	4.90 1.77	5.49 2.29	6.53 2.66	5.45 2.49
W2402364	5.23 2.10	5.29 2.15	5.30 2.26	4.52 2.01	4.68 1.89	5.20 2.07	5.09 2.15	6.29 3.02	5.22 2.39
W2402760	6.06 2.58	6.20 3.74	6.48 2.78	6.02 2.71	4.68 2.00	7.01 3.87	5.96 2.46	6.54 2.66	5.93 2.62
W2402764	5.70 1.98	6.01 2.08	5.66 2.01	5.42 2.25	4.49 1.79	4.36 1.92	5.57 2.10	6.27 2.10	5.48 2.35
W2402864	5.37 2.25	5.67 2.16	5.64 2.22	5.09 2.00	5.01 1.79	5.31 1.79	5.41 2.01	6.44 2.76	5.59 2.16
W2402964	4.46 2.17	4.68 2.31	4.66 2.28	4.04 2.03	3.41 1.70	0.00 0.00	4.08 1.97	5.31 2.52	4.17 2.35
W2408964	6.22 2.14	6.36 2.88	6.03 2.30	6.01 2.34	5.11 2.01	5.50 0.00	5.85 2.28	6.07 2.16	5.92 2.38
W2409064	5.41 2.47	5.35 2.56	5.71 2.53	4.89 2.42	4.57 2.03	4.08 1.32	5.06 2.20	6.32 2.89	5.28 2.56
W2414359	7.81 3.10	7.72 3.57	6.48 2.90	7.80 3.42	5.58 2.90	8.89 3.63	6.36 3.08	7.35 3.03	6.30 2.84
W2414364	5.91 2.44	5.36 2.39	5.38 2.21	5.84 2.59	4.58 2.10	0.00 0.00	5.10 2.44	6.09 2.49	5.52 2.73
W2414461	4.10 2.06	3.70 2.02	4.40 1.98	3.78 1.81	3.01 1.49	4.79 2.63	3.73 1.84	4.82 2.06	3.72 1.78
W2414464	4.07 2.04	3.22 0.97	4.16 1.75	3.68 1.72	3.24 1.34	0.00 0.00	3.75 1.75	4.43 1.85	4.17 1.95
W9303764	4.97 1.61	5.06 2.17	5.04 1.98	4.29 1.38	4.11 1.34	4.65 1.39	4.69 1.61	5.63 2.41	4.69 1.83
W9305862	4.17 1.93	4.18 2.29	4.46 2.51	3.43 1.92	3.14 1.51	3.76 1.77	3.96 1.85	4.79 2.93	4.19 2.31

TABLE 8. Mean U-Component (m/s) and Its Standard Deviation (m/s) by Weather Pattern Type; U > 0 From the East

STATION	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---	--- 6 ---	--- 7 ---	--- 8 ---	--- 9 ---
W1390264	0.73 2.08	0.85 2.49	0.32 2.54	0.31 1.98	1.21 1.76	0.96 1.49	1.23 2.18	0.02 2.93	0.01 2.64
W1396064	0.11 2.04	0.93 2.49	-0.05 2.57	0.41 2.15	1.10 1.94	0.50 1.69	1.04 2.31	-0.28 2.88	0.08 2.90
W1396764	0.28 2.30	1.04 2.64	-0.23 2.90	0.17 2.35	1.02 2.07	0.77 1.68	0.91 2.34	-0.50 3.01	-0.41 2.91
W1396860	0.19 1.82	0.45 2.38	-0.13 2.47	0.05 1.83	0.90 1.54	0.68 1.03	0.64 1.87	-0.04 2.75	-0.36 2.46
W1396864	0.55 1.96	1.24 2.32	-0.93 2.45	-0.23 2.09	0.81 1.80	0.62 1.57	0.93 1.97	-0.96 2.76	-0.36 3.00
W1399664	-0.24 2.73	1.27 3.45	-0.85 3.26	-0.81 2.94	1.03 2.82	0.21 2.16	0.86 3.04	-0.56 4.07	-0.73 3.70
W1492264	-1.01 2.81	0.39 3.15	-2.06 3.24	-1.10 2.67	0.59 2.66	0.69 1.70	0.52 3.05	-1.64 3.26	-1.20 3.45
W1493361	-1.15 2.73	-0.12 3.75	-1.96 3.81	-1.00 3.05	0.38 2.94	-0.21 2.11	0.42 3.17	-1.84 3.98	-1.03 3.85
W1493364	-1.17 2.96	0.18 2.80	-1.39 2.81	-0.98 2.65	0.54 2.58	0.00 2.10	0.22 2.56	-0.83 3.79	-1.36 3.09
W1493561	-0.43 2.78	-0.26 3.45	-0.59 3.25	-1.15 2.87	0.29 2.89	0.21 2.33	0.56 3.12	-0.90 3.94	-0.81 3.31
W1493564	-0.46 2.42	0.60 2.89	-0.90 3.01	-1.23 2.47	0.60 2.49	0.65 1.90	0.71 2.59	-1.69 3.22	-1.38 3.02
W1494064	-1.12 3.22	0.03 3.74	-2.49 3.33	-1.81 3.13	0.43 3.14	-0.22 2.08	0.28 3.33	-1.90 4.24	-1.83 3.94
W1494461	-0.16 2.49	0.10 3.35	-1.60 3.13	-1.11 2.73	1.14 2.51	2.01 2.91	0.77 2.80	-1.48 3.80	-1.09 3.68
W2302359	0.00 2.72	0.30 3.09	0.87 3.59	-0.12 2.62	1.35 2.68	1.63 2.02	1.18 2.83	-1.51 3.88	0.40 2.96
W2302364	-0.28 2.91	-0.32 3.26	-0.38 3.72	-0.10 2.70	1.01 2.63	1.30 2.21	0.79 3.12	-0.28 3.68	-0.30 3.30
W2304761	-1.13 2.93	0.30 2.77	-0.48 3.15	-1.08 2.83	-0.12 2.80	-0.40 2.01	0.25 3.19	-0.58 3.62	-0.80 2.87
W2304764	-1.76 2.93	-0.10 2.35	-0.52 3.74	-1.02 3.01	-0.70 2.93	-1.22 2.60	-0.60 3.31	-1.67 4.10	-1.79 3.35
W2304859	-2.22 3.27	-2.06 3.64	-0.11 4.38	-1.94 3.10	-1.08 3.12	-1.65 2.36	-0.78 3.57	-1.79 4.18	-1.53 3.22
W2304864	-2.09 2.76	-0.59 3.11	-0.73 3.41	-1.39 2.59	-0.92 2.80	-1.71 2.06	-0.93 3.04	-1.97 3.49	-1.42 2.95
W2305264	-0.65 2.37	-0.13 1.76	-0.72 2.44	-0.25 1.78	-0.10 1.63	0.06 1.62	-0.49 2.18	-1.13 2.61	-0.26 2.00
W2306260	-0.61 2.02	-0.62 2.37	-0.03 2.72	-0.51 2.10	-0.34 1.69	-0.77 2.50	0.03 2.02	-0.25 2.61	-0.46 2.44
W2306264	-0.49 1.93	0.29 1.94	-0.05 2.19	-0.26 1.68	-0.15 1.43	-1.88 3.14	-0.13 1.90	-0.02 1.93	-0.23 1.89
W2306564	-0.58 2.62	-0.53 3.15	-0.27 3.09	-1.48 2.63	-0.16 2.74	-0.28 2.35	0.28 2.94	-0.51 3.52	-0.92 2.87
W2401161	-0.81 3.51	-0.09 4.09	-1.86 4.07	-1.56 3.31	1.31 3.14	-1.29 2.47	0.99 3.90	-1.99 4.65	-1.15 4.03
W2402364	0.29 2.48	0.17 2.73	-0.36 2.76	-0.92 2.33	0.90 2.33	1.15 2.00	0.79 2.48	-0.79 3.41	-0.49 2.77
W2402760	-3.41 3.46	-3.83 4.42	-3.76 4.51	-4.10 3.83	-1.31 3.43	-4.62 5.44	-2.37 4.20	-3.26 4.59	-2.56 4.42
W2402764	-2.93 3.16	-4.34 3.96	-2.41 3.92	-3.43 3.30	-1.08 3.01	-2.48 2.85	-1.92 3.68	-3.29 4.06	-2.81 3.56
W2402864	-0.84 3.67	0.10 4.48	-0.89 3.96	-1.67 3.38	1.24 3.44	-0.27 4.06	0.52 3.73	-1.65 4.52	-1.18 3.94
W2402964	-1.82 2.61	-1.21 3.30	-2.15 2.73	-1.68 2.43	-0.34 2.29	0.00 0.00	-1.55 2.50	-2.72 3.16	-1.75 2.65
W2408964	-3.30 2.93	-3.38 3.10	-2.28 3.67	-3.24 2.97	-1.45 3.35	-2.90 0.00	-2.32 3.42	-2.10 3.70	-2.81 3.21
W2409064	-0.90 2.59	-0.27 2.91	-1.02 2.63	-1.11 2.37	0.79 2.19	0.03 2.56	0.03 2.52	-1.50 3.09	-0.81 2.61
W2414359	-4.77 3.55	-4.91 3.70	-3.29 3.74	-4.87 3.72	-1.68 3.76	-6.59 4.35	-2.60 3.88	-4.27 4.06	-3.43 3.32
W2414364	-3.25 3.13	-2.21 2.76	-2.72 3.18	-3.40 2.95	-1.43 2.83	0.00 0.00	-2.19 3.12	-3.42 3.34	-2.71 2.99
W2414461	-2.25 2.19	-2.14 1.98	-2.75 2.35	-2.35 2.10	-1.07 1.52	-3.26 3.04	-1.87 2.00	-3.09 2.42	-2.13 1.95
W2414464	-2.14 2.31	-1.56 1.39	-2.42 2.27	-2.19 2.16	-1.28 1.81	0.00 0.00	-1.92 2.21	-2.62 2.36	-2.50 2.32
W9303764	0.72 2.48	0.66 1.30	0.86 2.54	0.90 1.79	0.97 1.52	1.87 2.38	0.62 1.69	0.21 2.95	0.18 1.68
W9305862	-0.63 2.54	0.23 2.30	0.06 3.08	-0.44 2.32	0.30 2.09	-0.51 2.29	0.51 2.59	-0.08 3.13	-0.20 2.60

TABLE 9. Mean U-Component (m/s) and Its Standard Deviation (m/s) by Weather Pattern Type; U > 0 From the North

STATION	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---	--- 6 ---	--- 7 ---	--- 8 ---	--- 9 ---
W1390264	-1.69 3.60	-0.63 3.65	2.40 3.57	1.41 3.14	-1.33 3.26	-2.46 2.29	-0.77 3.61	1.15 3.96	0.33 4.08
W1396064	-3.03 4.15	-1.18 4.00	2.46 3.65	1.52 3.75	-2.41 3.64	-3.81 2.50	-1.72 3.99	-1.58 4.43	-0.78 4.30
W1396764	-3.24 4.65	-2.18 4.92	2.62 4.77	1.63 4.53	-2.82 4.16	-4.61 2.57	-2.08 4.61	0.93 5.56	-0.22 5.33
W1396860	-2.04 3.79	-0.35 4.10	2.56 3.76	1.82 3.64	-1.61 3.31	-3.02 2.18	-1.19 3.60	0.87 4.10	0.45 4.32
W1396864	-3.18 3.90	-2.54 3.48	1.78 3.70	1.36 3.80	-2.70 3.48	-3.67 2.40	-1.40 3.95	0.20 4.63	0.16 4.25
W1399664	-2.48 4.43	-1.88 4.32	2.33 3.77	1.53 3.43	-2.24 3.58	-4.11 3.06	-0.98 4.13	1.45 4.25	0.58 3.88
W1492264	-1.57 3.36	-1.70 3.54	1.41 3.37	1.25 2.92	-2.09 2.68	-2.76 1.94	-0.51 3.50	1.03 3.54	1.14 3.46
W1493361	-1.61 3.86	-0.99 4.23	2.52 3.62	1.71 3.20	-2.20 3.08	-3.62 2.32	-0.34 3.56	1.91 4.10	1.69 3.99
W1493364	-1.40 3.74	-1.56 2.94	1.79 3.20	1.14 2.97	-2.02 2.74	-2.55 2.22	-0.37 3.19	1.12 3.74	1.33 3.25
W1493561	-2.02 4.60	-1.58 4.75	2.43 4.06	1.55 3.69	-2.42 3.87	-3.50 3.74	-0.44 4.57	2.30 4.79	1.02 4.68
W1493564	-1.70 4.41	-2.45 3.71	1.81 3.67	1.34 3.66	-2.08 3.60	-1.19 4.30	-0.26 4.23	2.50 3.93	1.75 4.18
W1494064	-1.84 3.83	-1.72 4.23	2.14 3.58	1.70 3.26	-2.39 3.21	-3.06 3.23	-0.48 3.94	1.50 4.63	1.30 4.00
W1494461	-1.83 3.55	-1.11 4.14	2.30 3.25	1.57 3.25	-1.82 3.28	-2.55 2.67	-0.53 3.76	1.36 4.16	1.80 3.71
W2302359	-1.97 2.80	-0.74 2.89	1.38 3.03	0.05 3.05	-1.27 2.83	-2.49 2.15	-1.28 2.95	-0.06 2.68	-1.11 2.84
W2302364	-2.35 3.28	-0.50 3.41	1.26 3.41	-0.20 3.71	-1.87 3.36	-3.24 2.41	-1.25 3.72	-1.47 3.80	-1.11 3.27
W2304761	-1.97 4.24	-1.94 3.86	0.07 4.33	0.36 3.99	-1.82 3.87	-3.08 3.04	-1.80 3.69	0.13 4.68	-0.51 4.53
W2304764	-2.41 4.20	0.40 3.24	1.53 4.71	-0.65 4.53	-3.01 4.26	-3.76 3.20	-2.44 4.34	-0.27 5.78	-0.69 4.88
W2304859	-1.55 3.24	-1.43 3.00	0.79 3.14	-0.83 2.88	-1.83 2.96	-2.15 2.68	-1.36 3.08	-0.18 2.95	-0.80 3.45
W2304864	-1.53 2.75	-0.31 2.25	0.36 3.04	-0.72 2.76	-1.44 2.77	-2.35 2.62	-1.18 2.91	-0.70 3.21	-0.41 2.97
W2305264	-0.71 3.23	-1.16 3.46	-0.15 3.64	0.41 3.11	-0.64 2.88	-0.60 2.63	-0.91 3.06	-0.03 4.24	0.56 4.15
W2306260	-1.40 2.98	-0.83 3.41	0.32 3.13	-1.22 2.93	-1.57 2.78	-1.81 2.01	-0.58 2.96	0.57 3.62	-0.30 3.50
W2306264	-0.77 2.42	-0.73 2.18	0.20 2.61	-1.12 2.36	-1.18 2.19	-0.56 2.75	-0.48 2.49	0.96 3.37	-0.49 2.71
W2306564	-1.14 4.54	-1.32 5.09	2.11 4.33	0.58 3.70	-2.38 3.94	-2.09 4.66	-0.62 4.29	2.41 4.87	0.80 4.54
W2401161	-0.22 3.46	-0.60 3.37	2.14 2.90	1.50 2.80	-1.44 2.84	0.56 3.85	-0.04 3.35	1.70 3.82	1.21 3.24
W2402364	-0.97 4.01	-0.56 3.98	2.45 3.66	1.64 3.24	-1.53 3.50	-1.10 4.41	0.00 4.00	2.62 4.75	1.38 4.20
W2402760	-1.80 2.51	-1.57 2.07	-0.50 2.41	-1.24 2.06	-0.87 2.15	-1.53 2.04	-1.09 2.69	-0.58 2.85	-0.91 2.60
W2402764	-1.91 2.35	-0.43 1.72	-1.01 2.51	-1.43 2.11	-1.01 2.34	-1.48 1.36	-1.30 2.87	-0.73 2.78	-1.57 2.29
W2402864	0.99 2.90	0.15 3.10	2.04 2.78	1.63 2.56	-0.40 2.87	0.41 3.01	0.75 2.96	2.36 3.48	1.69 2.94
W2402964	0.74 2.17	0.38 2.40	1.42 2.23	0.73 2.12	-0.03 1.83	0.00 0.00	0.61 2.01	1.58 2.54	0.72 2.27
W2408964	-1.69 3.17	-2.39 3.93	-0.28 3.67	-1.73 3.51	-1.02 2.95	-3.30 0.00	-1.12 3.34	-0.20 3.81	-1.22 3.62
W2409064	1.45 4.01	0.34 4.03	3.20 3.68	2.22 3.44	-0.65 3.64	0.13 2.38	1.19 3.77	3.41 4.23	2.18 4.00
W2414359	-2.68 4.05	-3.21 4.19	-0.43 3.92	-3.27 4.13	-1.73 3.62	-3.69 3.44	-1.46 4.16	-0.87 4.18	-1.67 3.76
W2414364	-1.71 3.24	-2.35 3.11	-1.04 3.02	-2.25 3.25	-1.69 2.79	0.00 0.00	-1.33 3.18	-1.63 3.40	-1.97 3.57
W2414461	0.14 1.87	0.04 1.91	0.76 1.70	0.22 1.38	0.30 1.52	0.28 1.57	0.44 1.81	0.55 2.09	0.37 1.58
W2414464	0.17 2.09	0.38 1.32	0.34 1.66	0.17 1.38	0.40 1.39	0.00 0.00	0.26 1.61	0.24 1.97	0.16 1.79
W9303764	1.29 3.06	1.27 3.82	1.32 3.18	1.24 2.56	0.40 2.81	1.19 2.84	0.74 3.11	2.23 3.79	1.80 3.18
W9305862	0.13 2.06	0.47 2.73	0.75 2.81	0.31 1.91	-0.20 1.57	-0.33 1.80	0.03 1.99	1.16 3.46	0.69 2.72

TABLE 10. Square Root of Mean Squared Speed (m/s) and Its Standard Deviation (m/s)
by Weather Pattern Type

STATION	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---	--- 6 ---	--- 7 ---	--- 8 ---	--- 9 ---
W1390264	4.99 2.01	4.98 1.98	5.20 2.23	4.25 1.82	4.40 1.76	4.25 1.59	4.92 1.94	5.45 2.11	5.13 2.32
W1396064	5.94 1.93	5.65 1.96	5.47 1.98	4.87 1.89	5.16 1.76	5.25 1.54	5.52 1.77	6.16 1.83	5.68 2.11
W1396764	6.72 2.04	6.50 2.12	6.49 2.32	5.69 1.93	5.87 1.78	6.06 1.57	6.31 1.87	6.93 2.33	6.52 2.45
W1396860	5.12 1.96	5.16 1.79	5.38 2.19	4.64 1.94	4.29 1.60	4.19 1.44	4.71 1.67	5.25 2.01	5.20 2.33
W1396864	5.83 2.05	5.64 1.91	5.33 1.65	4.89 1.75	5.15 1.71	5.13 1.46	5.24 1.81	6.14 1.80	5.65 1.98
W1399664	6.29 2.36	6.45 2.11	6.03 2.04	5.20 1.82	5.52 1.94	5.92 1.91	5.85 2.07	6.58 2.16	5.80 2.28
W1492264	5.13 2.06	5.49 1.95	5.51 2.02	4.54 1.77	4.56 1.70	4.49 1.62	5.13 1.88	5.50 2.08	5.25 2.20
W1493361	5.72 1.95	6.24 2.14	6.42 2.21	5.11 1.89	5.07 1.61	5.19 1.71	5.34 1.87	6.49 2.38	6.01 2.37
W1493364	5.41 2.26	4.81 1.96	5.05 1.96	4.48 1.77	4.58 1.60	4.60 1.68	4.51 1.75	5.66 2.36	5.01 1.88
W1493561	6.37 2.16	6.76 1.98	6.18 2.06	5.41 1.89	5.68 1.90	6.15 1.62	6.09 2.14	7.02 2.35	6.20 2.27
W1493564	5.87 2.09	5.73 1.98	5.57 1.88	5.05 1.99	5.19 1.78	5.29 1.77	5.55 2.02	6.19 2.54	5.73 2.33
W1494064	5.91 2.01	6.37 2.27	6.14 2.06	5.36 1.95	5.33 1.85	5.43 1.59	5.60 2.02	6.92 2.49	6.10 2.39
W1494461	5.25 1.88	5.82 2.31	5.69 2.12	4.82 2.05	4.85 1.84	5.61 1.58	5.16 1.93	6.33 2.30	5.59 2.68
W2302359	4.97 1.40	4.86 1.37	5.41 1.56	4.44 1.33	4.67 1.34	4.67 1.20	5.00 1.38	5.57 2.02	4.85 1.44
W2302364	5.57 1.67	5.59 1.72	5.72 1.85	5.05 1.61	5.17 1.58	5.28 1.39	5.82 1.70	5.96 1.89	5.35 1.75
W2304761	6.10 2.04	5.57 1.45	5.94 1.97	5.38 2.13	5.51 1.84	5.29 1.62	5.84 1.73	6.57 2.28	5.84 2.36
W2304764	6.70 2.01	5.73 2.25	6.75 2.34	6.09 2.11	6.52 1.96	6.34 1.73	6.77 2.07	8.04 2.56	6.82 2.48
W2304859	6.16 1.78	5.86 2.01	6.12 1.95	5.32 1.57	5.44 1.56	5.32 1.39	5.85 1.52	6.08 1.81	5.80 1.80
W2304864	5.37 1.64	4.37 1.43	5.26 1.77	4.62 1.57	4.76 1.59	5.01 1.40	5.23 1.78	5.82 1.88	5.03 1.96
W2305264	4.91 2.35	4.77 2.27	5.14 2.49	4.14 2.27	4.04 2.02	4.16 1.93	4.74 2.12	5.64 2.83	5.05 2.81
W2306260	5.45 1.77	5.70 1.91	5.57 1.90	5.23 1.65	4.80 1.57	5.30 1.80	5.12 1.63	5.72 2.20	5.55 2.04
W2306264	4.57 1.52	4.68 1.47	4.51 1.57	4.23 1.20	3.94 1.22	5.35 2.14	4.47 1.56	4.88 1.78	4.37 1.65
W2306564	6.17 2.14	6.72 2.36	6.22 2.23	5.39 1.85	5.79 1.96	6.01 2.30	5.97 2.06	6.86 2.66	5.94 2.42
W2401161	5.72 2.19	5.97 2.39	6.12 2.45	5.17 2.22	5.01 1.96	5.35 1.91	5.77 2.29	6.83 2.65	5.77 2.50
W2402364	5.55 2.14	5.61 2.20	5.64 2.32	4.84 2.12	4.94 1.93	5.48 2.08	5.40 2.20	6.61 3.08	5.54 2.46
W2402760	6.42 2.67	6.55 3.90	6.76 2.82	6.28 2.77	4.93 2.09	7.27 3.95	6.27 2.54	6.89 2.77	6.20 2.69
W2402764	5.97 2.03	6.21 2.15	5.92 2.05	5.61 2.28	4.69 1.86	4.60 2.11	5.84 2.16	6.52 2.12	5.69 2.38
W2402864	5.69 2.32	5.97 2.22	5.97 2.29	5.38 2.09	5.25 1.82	5.57 1.86	5.71 2.08	6.78 2.85	5.91 2.24
W2402964	4.89 2.33	5.06 2.47	5.06 2.39	4.38 2.18	3.71 1.83	0.00 0.00	4.46 2.12	5.80 2.61	4.54 2.43
W2408964	6.58 2.18	6.70 2.86	6.36 2.38	6.27 2.35	5.39 2.06	6.10 0.00	6.18 2.33	6.43 2.25	6.25 2.44
W2409064	5.82 2.57	5.76 2.65	6.09 2.57	5.25 2.51	4.89 2.10	4.41 1.31	5.43 2.28	6.72 2.89	5.65 2.60
W2414359	8.17 3.09	8.00 3.53	6.81 2.94	8.05 3.40	5.83 2.93	9.15 3.64	6.66 3.09	7.66 3.08	6.58 2.84
W2414364	6.16 2.48	5.61 2.41	5.63 2.27	6.05 2.60	4.78 2.14	0.00 0.00	5.35 2.49	6.39 2.52	5.76 2.75
W2414461	4.48 2.19	4.07 2.20	4.76 2.06	4.11 1.92	3.29 1.61	5.18 2.65	4.06 1.95	5.21 2.13	4.07 1.87
W2414464	4.44 2.11	3.53 1.17	4.53 1.83	3.99 1.85	3.57 1.45	0.00 0.00	4.09 1.86	4.85 1.92	4.54 2.04
W9303764	5.30 1.73	5.30 2.20	5.35 2.06	4.53 1.46	4.35 1.44	4.94 1.51	4.98 1.71	5.94 2.46	4.97 1.92
W9305862	4.64 2.07	4.55 2.38	4.89 2.63	3.79 2.03	3.45 1.63	4.12 1.91	4.35 1.99	5.25 3.01	4.61 2.43

TABLE 11. Cube Root of Mean Cubed Speed (m/s) and Its Standard Deviation (m/s)
by Weather Pattern Type

STATION	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---	--- 6 ---	--- 7 ---	--- 8 ---	--- 9 ---
W1390264	5.21 2.06	5.18 2.01	5.43 2.25	4.44 1.88	4.59 1.79	4.46 1.64	5.12 1.97	5.68 2.17	5.34 2.35
W1396064	6.10 1.91	5.84 1.96	5.67 1.99	5.06 1.91	5.31 1.75	5.38 1.54	5.68 1.77	6.35 1.84	5.87 2.14
W1396764	6.91 2.07	6.67 2.14	6.69 2.33	5.87 1.97	6.02 1.81	6.21 1.59	6.50 1.89	7.12 2.37	6.72 2.50
W1396860	5.33 2.00	5.36 1.83	5.59 2.21	4.83 2.00	4.46 1.64	4.37 1.49	4.91 1.70	5.43 2.03	5.41 2.39
W1396864	6.00 2.08	5.80 1.95	5.51 1.68	5.05 1.79	5.31 1.74	5.29 1.49	5.42 1.85	6.30 1.83	5.85 2.04
W1399664	6.53 2.37	6.68 2.12	6.27 2.05	5.41 1.85	5.74 1.95	6.14 1.90	6.07 2.08	6.80 2.17	6.01 2.29
W1492264	5.34 2.09	5.68 1.97	5.71 2.04	4.71 1.78	4.74 1.71	4.69 1.59	5.32 1.89	5.68 2.11	5.43 2.20
W1493361	5.90 1.99	6.41 2.17	6.61 2.25	5.27 1.92	5.22 1.64	5.34 1.75	5.53 1.90	6.66 2.39	6.17 2.38
W1493364	5.61 2.30	5.00 2.00	5.22 1.99	4.64 1.81	4.75 1.62	4.76 1.71	4.69 1.80	5.84 2.38	5.17 1.87
W1493561	6.57 2.16	6.95 1.98	6.40 2.09	5.60 1.94	5.85 1.91	6.35 1.60	6.29 2.16	7.23 2.37	6.40 2.29
W1493564	6.06 2.10	5.91 1.99	5.79 1.93	5.24 2.03	5.36 1.80	5.52 1.79	5.75 2.04	6.38 2.58	5.93 2.36
W1494064	6.10 2.03	6.57 2.29	6.32 2.06	5.53 1.97	5.51 1.86	5.61 1.59	5.79 2.05	7.10 2.49	6.27 2.38
W1494461	5.47 1.92	6.03 2.34	5.95 2.16	5.03 2.10	5.02 1.87	5.79 1.62	5.37 1.95	6.55 2.32	5.79 2.70
W2302359	5.18 1.44	5.04 1.43	5.60 1.58	4.62 1.37	4.83 1.37	4.86 1.23	5.19 1.42	5.77 2.07	5.04 1.49
W2302364	5.78 1.70	5.86 1.82	5.93 1.89	5.24 1.66	5.36 1.61	5.50 1.41	6.02 1.74	6.18 1.95	5.57 1.81
W2304761	6.29 2.07	5.71 1.47	6.16 2.01	5.57 2.18	5.69 1.86	5.47 1.64	6.04 1.76	6.79 2.32	6.04 2.38
W2304764	6.92 2.03	5.97 2.30	6.99 2.37	6.30 2.16	6.71 1.97	6.55 1.77	7.00 2.13	8.27 2.58	7.06 2.53
W2304859	6.36 1.82	6.02 2.07	6.33 2.00	5.50 1.63	5.62 1.60	5.53 1.47	6.06 1.55	6.28 1.87	5.99 1.85
W2304864	5.58 1.72	4.67 1.47	5.47 1.85	4.80 1.65	4.94 1.64	5.20 1.46	5.45 1.86	6.05 1.96	5.24 2.05
W2305264	5.24 2.45	5.07 2.48	5.47 2.59	4.40 2.45	4.32 2.13	4.52 2.06	5.06 2.24	5.98 2.90	5.36 2.88
W2306260	5.74 1.84	5.98 1.99	5.87 1.98	5.50 1.73	5.03 1.63	5.66 1.95	5.39 1.71	6.03 2.30	5.83 2.12
W2306264	4.82 1.63	4.99 1.64	4.73 1.67	4.43 1.28	4.11 1.30	5.57 2.16	4.70 1.68	5.12 1.87	4.60 1.75
W2306564	6.42 2.17	6.97 2.38	6.48 2.28	5.62 1.91	6.00 1.99	6.24 2.35	6.20 2.10	7.12 2.71	6.19 2.46
W2401161	5.99 2.21	6.26 2.41	6.40 2.47	5.42 2.27	5.23 1.98	5.69 2.07	6.02 2.30	7.09 2.66	6.04 2.51
W2402364	5.83 2.19	5.89 2.25	5.93 2.38	5.10 2.20	5.17 1.98	5.72 2.10	5.68 2.26	6.89 3.14	5.81 2.53
W2402760	6.73 2.76	6.88 4.03	7.01 2.87	6.50 2.84	5.15 2.18	7.51 4.03	6.55 2.62	7.19 2.87	6.45 2.76
W2402764	6.22 2.08	6.40 2.23	6.15 2.10	5.79 2.31	4.88 1.93	4.76 2.24	6.08 2.21	6.74 2.13	5.89 2.40
W2402864	5.97 2.40	6.22 2.30	6.26 2.35	5.64 2.18	5.47 1.86	5.80 1.95	5.97 2.14	7.07 2.94	6.18 2.33
W2402964	5.26 2.49	5.40 2.59	5.39 2.51	4.67 2.31	3.96 1.95	0.00 0.00	4.79 2.27	6.20 2.70	4.86 2.52
W2408964	6.90 2.23	7.00 2.85	6.65 2.46	6.51 2.38	5.65 2.11	6.50 0.00	6.48 2.39	6.73 2.34	6.53 2.49
W2409064	6.17 2.65	6.10 2.73	6.42 2.62	5.55 2.59	5.16 2.16	4.75 1.34	5.75 2.35	7.06 2.91	5.96 2.64
W2414359	8.48 3.09	8.25 3.50	7.11 2.98	8.26 3.40	6.06 2.97	9.36 3.66	6.94 3.11	7.94 3.14	6.83 2.86
W2414364	6.40 2.53	5.83 2.42	5.86 2.33	6.24 2.62	4.96 2.18	0.00 0.00	5.57 2.55	6.64 2.55	5.97 2.77
W2414461	4.81 2.31	4.39 2.33	5.07 2.14	4.39 2.01	3.54 1.72	5.54 2.68	4.35 2.06	5.54 2.20	4.37 1.96
W2414464	4.75 2.18	3.86 1.36	4.85 1.91	4.26 1.96	3.86 1.56	0.00 0.00	4.39 1.97	5.22 1.99	4.85 2.12
W9303764	5.58 1.85	5.53 2.25	5.62 2.14	4.74 1.54	4.57 1.53	5.18 1.61	5.22 1.80	6.21 2.53	5.20 2.00
W9305862	5.03 2.21	4.87 2.45	5.25 2.74	4.11 2.14	3.71 1.74	4.44 2.02	4.68 2.12	5.61 3.07	4.96 2.53

TABLE 12. Mean 12-Hour Maximum Wind Speed (m/s) and Its Standard Deviation (m/s) by Weather Pattern Type

STATION	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---	--- 6 ---	--- 7 ---	--- 8 ---	--- 9 ---
W1390264	7.19 2.75	7.04 2.61	7.43 2.90	6.12 2.54	6.31 2.39	6.24 2.37	7.02 2.66	7.74 2.87	7.26 2.97
W1396064	8.05 2.28	7.89 2.44	7.68 2.39	6.91 2.40	7.10 2.06	7.10 1.91	7.56 2.21	8.37 2.25	7.95 2.63
W1396764	9.18 2.75	8.81 2.80	8.91 2.93	7.85 2.61	8.00 2.43	8.29 2.27	8.74 2.57	9.37 3.08	9.00 3.26
W1396860	7.37 2.77	7.30 2.51	7.62 2.89	6.62 2.74	6.16 2.27	6.05 2.07	6.85 2.27	7.37 2.78	7.39 3.20
W1396864	8.02 2.65	7.83 2.71	7.43 2.27	6.87 2.36	7.22 2.32	7.22 2.01	7.37 2.53	8.30 2.36	8.06 2.74
W1399664	8.89 2.99	8.97 2.66	8.58 2.59	7.45 2.41	7.88 2.51	8.40 2.32	8.35 2.70	9.15 2.74	8.14 2.89
W1492264	7.33 2.79	7.70 2.55	7.69 2.50	6.42 2.23	6.49 2.19	6.42 2.04	7.31 2.48	7.64 2.70	7.30 2.66
W1493361	8.01 2.71	8.52 2.75	8.81 2.79	7.07 2.45	7.01 2.21	7.20 2.41	7.57 2.57	8.74 2.87	8.07 2.87
W1493364	7.62 2.94	6.87 2.78	6.98 2.56	6.28 2.33	6.51 2.14	6.49 2.29	6.50 2.54	7.71 3.07	6.98 2.22
W1493561	8.80 2.73	9.21 2.46	8.67 2.65	7.60 2.62	7.80 2.43	8.60 1.90	8.50 2.75	9.59 3.00	8.52 2.88
W1493564	8.16 2.58	7.84 2.40	7.99 2.56	7.19 2.66	7.28 2.29	7.86 2.10	7.94 2.67	8.48 3.13	8.04 3.10
W1494064	8.13 2.61	8.74 2.92	8.31 2.53	7.33 2.47	7.40 2.36	7.65 2.10	7.73 2.67	9.21 3.07	8.19 2.76
W1494461	7.61 2.60	8.19 3.02	8.29 2.81	6.95 2.76	6.86 2.46	7.98 2.15	7.44 2.56	8.83 2.98	7.86 3.38
W2302359	7.25 2.12	6.87 2.15	7.65 2.12	6.43 2.00	6.62 1.92	6.86 1.84	7.20 2.07	8.01 2.76	7.04 2.20
W2302364	8.02 2.31	8.32 2.53	8.18 2.58	7.26 2.33	7.38 2.19	7.67 1.93	8.32 2.41	8.54 2.85	7.77 2.67
W2304761	8.49 2.73	7.38 1.89	8.52 2.76	7.66 2.95	7.66 2.46	7.56 2.12	8.25 2.36	9.20 3.07	8.22 3.04
W2304764	9.43 2.67	8.23 3.23	9.52 2.87	8.62 2.79	9.04 2.47	9.03 2.48	9.60 2.99	10.90 3.14	9.74 3.48
W2304859	8.53 2.48	8.09 2.73	8.52 2.74	7.43 2.33	7.52 2.22	7.63 2.20	8.21 2.19	8.44 2.63	8.09 2.49
W2304864	7.69 2.57	7.04 2.44	7.52 2.65	6.61 2.46	6.69 2.38	7.10 2.08	7.57 2.82	8.28 2.90	7.23 2.96
W2305264	7.44 3.45	7.06 3.74	7.78 3.60	6.13 3.56	6.21 3.05	6.84 3.03	7.16 3.25	8.39 3.96	7.59 3.78
W2306260	8.33 2.65	8.56 3.03	8.55 2.98	7.91 2.66	7.16 2.38	8.38 3.11	7.82 2.63	8.81 3.37	8.39 3.02
W2306264	7.06 2.63	7.55 2.82	6.76 2.53	6.33 2.08	5.85 2.11	7.92 2.77	6.87 2.67	7.39 2.75	6.74 2.72
W2306564	8.90 2.88	9.52 3.11	8.96 3.04	7.84 2.67	8.15 2.60	8.52 3.25	8.54 2.82	9.68 3.52	8.58 3.25
W2401161	8.41 2.79	8.77 3.05	8.93 3.14	7.57 2.89	7.28 2.58	8.40 2.95	8.30 2.92	9.58 3.23	8.44 3.17
W2402364	8.33 2.97	8.39 3.08	8.41 3.25	7.35 3.06	7.30 2.71	8.05 2.79	8.14 3.13	9.58 4.05	8.23 3.38
W2402760	9.63 3.88	9.99 5.56	9.64 3.76	8.86 3.79	7.28 3.22	10.16 5.21	9.19 3.63	9.95 3.93	8.88 3.69
W2402764	8.68 2.91	8.53 3.11	8.40 2.73	7.76 3.04	6.74 2.77	6.38 3.58	8.37 2.98	9.17 2.73	7.93 3.13
W2402864	8.55 3.37	8.63 3.30	8.89 3.25	8.01 3.13	7.59 2.61	8.08 2.73	8.46 3.03	9.76 3.96	8.71 3.28
W2402964	7.99 3.89	7.89 3.63	7.93 3.58	6.85 3.44	5.88 3.01	0.00 0.00	7.26 3.61	9.17 3.80	7.21 3.74
W2408964	9.91 3.17	9.87 3.57	9.41 3.43	9.02 3.09	8.03 2.95	9.30 0.00	9.20 3.26	9.53 3.31	9.21 3.42
W2409064	8.95 3.61	8.82 3.80	9.14 3.40	7.98 3.44	7.42 2.97	7.21 1.99	8.32 3.29	9.82 3.63	8.54 3.49
W2414359	11.67 3.96	11.02 4.20	9.93 3.86	10.82 4.01	8.40 3.86	12.35 4.74	9.67 3.95	10.90 4.24	9.44 3.66
W2414364	8.85 3.35	8.10 2.95	8.13 3.15	8.40 3.26	6.86 2.94	0.00 0.00	7.76 3.40	9.10 3.39	8.25 3.50
W2414461	7.41 3.58	6.82 3.69	7.57 3.12	6.58 2.93	5.44 2.71	8.27 3.73	6.63 3.13	8.20 3.15	6.66 2.95
W2414464	7.19 3.05	6.34 2.61	7.33 2.76	6.43 2.99	6.02 2.55	0.00 0.00	6.67 3.00	8.00 2.99	7.29 3.08
W9303764	8.17 2.92	7.86 2.88	8.06 3.03	6.78 2.37	6.55 2.38	7.48 2.48	7.49 2.64	8.81 3.34	7.39 2.87
W9305862	7.75 3.35	7.22 3.30	7.88 3.94	6.30 3.16	5.65 2.67	6.74 3.10	7.10 3.24	8.27 4.01	7.54 3.56

RESULTS

Both the frequency of occurrence of the weather pattern type and the mean wind speed show variations from year to year. An important application of the weather pattern type climatology is to use the interannual variability of the weather pattern type frequency to adjust the observed speed to represent the long-term mean speed. This has meaning only if the year-to-year variability of the mean speed for a given weather pattern type is much less than the year-to-year variability of the frequency of occurrence of the weather pattern type. Figure 10 shows a scatter diagram of the variability of frequency of occurrence and speed for each weather pattern type. Variability is defined as the ratio of the standard deviation of the yearly values divided by the mean of the yearly values. For only a few stations and weather pattern types is the variability of the wind speed greater than that of the frequency of

FIGURE 10. Scatter Diagrams by Weather Pattern Type of the Variability of Wind Speed (Ordinate) Versus the Variability of Frequency of Occurrence (Abscissa)

occurrence. Over all weather pattern types, the speed variability averaged 39% of the frequency variability. The large scatter and high values of the variability shown in Figure 10 for Types 2, 6, 8 and 9 are due to the low frequency of occurrence of these types, especially at the northern stations. Even for these types, the clustering of a large portion of the points about a low value of the wind variability indicate that where a weather pattern type has importance (i.e., high frequency of occurrence), wind variability is much less than the variability of the frequency of weather pattern occurrence.

Figures 11 and 12, for the same two stations used to portray the monthly trends in weather pattern type frequency, show the interannual variability of the frequency of occurrence and mean wind speed by weather pattern type. The high variability of the frequency of occurrence and the relatively small change in mean speed for a weather pattern type is clearly seen in these figures.

FIGURE 11. Interannual Variability in Frequency of Occurrence (dashed) and Mean Wind Speed (solid) for Rapid City, South Dakota

FIGURE 12. Interannual Variability in Frequency of Occurrence (dashed) and Mean Wind Speed (solid) for Oklahoma City, Oklahoma

Mean wind speeds at a station are often nearly the same for pairs of weather pattern types (Table 7). Student's t-test was applied to test the hypothesis that the mean speeds of pairs of weather pattern types were obtained from the same population of wind speed observations. When this hypothesis is accepted, it means stratification by that pair of weather pattern types did not yield substantially different populations of wind observations. Table 13 summarizes the results of the student's t-test for 37 stations/periods of record. For only 14 out of 37 pairs of weather pattern types is the probability greater than 25% that the two mean wind speeds are from the same population; for 10 pairs it is less than 10%. On the basis of a comparison of just the mean wind speeds, stratification by weather pattern type yields distinctly different wind speeds for about one-third of the

TABLE 13. Mean Probability (%) from 37 Stations That the Mean Wind Speed From the Indicated Pairs of Weather Pattern Types Are From the Same Population of Speed Observations

TYPE	9	8	7	TYPE 6	5	4	3	2
1	31.	15.	25.	22.	1.	6.	29.	44.
2	49.	27.	48.	31.	21.	27.	40.	
3	29.	17.	21.	17.	1.	1.		
4	12.	4.	14.	36.	21.			
5	5.	1.	5.	32.				
6	22.	8.	28.					
7	49.	9.						
8	13.							

possible pairs of weather pattern types. Additional tests of the strength of the stratification, such as a chi-square test on the joint speed-direction frequency distribution, have not been done.

During the early 1960s, the anemometers at many airport National Weather Service stations were moved from rooftop locations to ground masts located on the grass strips between or alongside airport runways. Two periods of record, one for each anemometer height and location, were analyzed for ten stations (see Table 5) in this study. Using wind speed statistics from two anemometer heights, it is possible to determine the apparent change with height of the long-term mean wind speed. Table 14 gives the mean wind speed observed at the two anemometer heights and the corresponding power-law wind shear exponent (α) calculated from:

$$\alpha = \frac{\ln(V_1/V_2)}{\ln(Z_1/Z_2)}$$

where Z_1 and Z_2 are the two anemometer heights and V_1 and V_2 are the two mean wind speeds at these heights. Also noted in Table 14 is the location of the anemometer. In all cases, the change in anemometer height is accompanied by a change in location from rooftop (R) to ground mast (G).

TABLE 14. Apparent Power Law Shear Exponent for the Long-Term Mean Wind Speed at Ten Great Plains Locations. Wind speeds are in m/s. Anemometer heights are in ft AGL.

Type	1	2	3	4	5	6	7	8
W24143	Great Falls, MT			$Z_1 = 75'$ R			$Z_2 = 22'$ G	
V_1	7.81	7.72	6.48	7.80	5.58	-	6.36	7.35
V_2	5.91	5.36	5.38	5.84	4.58	-	5.10	6.09
α	0.227	0.297	0.152	0.236	0.161		0.180	0.153
W24144	Helena, MT			$Z_1 = 44'$ R			$Z_2 = 20'$ G	
V_1	4.09	3.70	4.40	3.78	3.01	-	3.73	4.82
V_2	4.07	3.22	4.16	3.68	3.24	-	3.75	4.43
α	0.006	0.176	0.071	0.034	0.093		0.007	0.107
W24027	Rock Springs, WY			$Z_1 = 50'$ R			$Z_2 = 20'$ G	
V_1	6.06	6.20	6.48	6.02	4.68	7.01	5.96	6.54
V_2	5.70	6.01	5.66	5.42	4.49	4.36	5.57	6.27
α	0.067	0.034	0.148	0.115	0.045	0.518	0.074	0.046
W23062	Denver, CO			$Z_1 = 72'$ R			$Z_2 = 20'$ G	
V_1	5.12	5.40	5.23	4.92	4.54	4.86	4.81	5.34
V_2	4.29	4.32	4.26	4.01	3.74	5.12	4.20	4.61
α	0.138	0.174	0.160	0.160	0.151	0.041	0.106	0.115
W14935	Grand Island, NE			$Z_1 = 47'$ R			$Z_2 = 20'$ G	
V_1	6.15	6.53	5.93	5.18	5.50	5.92	5.86	6.78
V_2	5.65	5.51	5.31	4.83	5.00	5.06	5.34	5.93
α	0.099	0.199	0.129	0.082	0.112	0.184	0.109	0.157

TABLE 14 (continued)

Type	1	2	3	4	5	6	7	8
W14933	Des Moines, IA			$Z_1 = 69' \text{ R}$		$Z_2 = 20' \text{ G}$		
V_1	5.51	6.06	6.21	4.93	4.92	5.03	5.14	6.29
V_2	5.19	4.61	4.85	4.29	4.39	4.43	4.31	5.45
α	0.048	0.221	0.200	0.112	0.092	0.103	0.142	0.116
W23048	Tucumcari, NM			$Z_1 = 32' \text{ R}$		$Z_2 = 22' \text{ G}$		
V_1	5.94	5.67	5.90	5.12	5.24	5.09	5.62	5.86
V_2	5.12	4.06	5.01	4.41	4.57	4.80	4.98	5.54
α	0.396	0.891	0.436	0.398	0.365	0.157	0.323	0.150
W23047	Amarillo, TX			$Z_1 = 33' \text{ R}$		$Z_2 = 23' \text{ G}$		
V_1	5.89	5.42	5.69	5.17	5.32	5.09	5.61	6.31
V_2	6.45	5.52	6.49	5.85	6.30	6.12	6.52	7.80
α	<0	<0	<0	<0	<0	<0	<0	<0
W23023	Midland, TX			$Z_1 = 35' \text{ R}$		$Z_2 = 22' \text{ G}$		
V_1	4.75	4.65	5.20	4.24	4.49	4.46	4.79	5.34
V_2	5.34	5.29	5.48	4.84	4.97	5.05	5.58	5.71
α	<0	<0	<0	<0	<0	<0	<0	<0
W13968	Tulsa, OK			$Z_1 = 39' \text{ R}$		$Z_2 = 23' \text{ G}$		
V_1	4.89	4.92	5.14	4.42	4.10	4.01	4.50	5.04
V_2	5.63	5.44	5.12	4.71	4.98	4.96	5.05	5.97
α	<0	<0	0.007	<0	<0	<0	<0	<0

To properly interpret the shear exponent given in Table 14, it is necessary to recognize that the wind regime is very sensitive to the local surroundings of the measurement site. Thus, the buildings in the vicinity of the building on which the anemometer is located act as roughness elements to the wind and often cause such a marked reduction in wind speed, even at anemometer height, that a change in location to an unobstructed airport runway setting will result in a higher mean wind speed in the new location. Any location that shows unusually small or large shear exponents must be evaluated very carefully. Amarillo and Midland, Texas, where the anemometer height change is only about 10 feet, and Tulsa, Oklahoma, have very unrealistic negative shear exponents for all weather pattern types. This is most likely caused by the decrease in surface roughness in the change to the airport location. Denver, Colorado, and Helena, Montana, have negative shear exponents for some weather pattern types. At Denver, the negative shear for Type 6 is probably the result of the very small sample size available for this type, only 0.79% of observations in the first period and 0.67% in the second. At Helena the sample size is not the problem. Here it is the sensitivity of the wind speed to the directional variation of anemometer exposure. Figures 13 and 14 show the directional frequency for each weather pattern type and the mean wind speed from that direction for the two periods of record from Helena, Montana. Notice that for weather pattern Type 5, the directional frequencies for the two periods are very similar but the winds from the east are much higher in the first period than in the second. The wind speed from the prevailing direction, which is the same for both periods, is much less during the first period in comparison to the second. These differences in response to wind direction are most often caused by changes in anemometer exposure that are highly site-specific.

FIGURE 13. Wind Direction Frequency and Mean Wind Speed by Direction for the Period January 1, 1955 to September 19, 1961 at Helena, Montana. Anemometer height is 44 feet AGL on rooftop mast.

FIGURE 14. Wind Direction Frequency and Mean Wind Speed by Direction for the Period September 20, 1961 to December 31, 1964 at Helena, Montana. Anemometer height is 20 feet AGL on ground mast.

DISCUSSION AND CONCLUSIONS

WEATHER PATTERN CLIMATOLOGY

The synoptic model presented in Figure 1 and the abbreviated definitions given in Table 1 provide a useful framework for stratifying Great Plains weather patterns. However, considerable experience with synoptic meteorology is essential in order to consistently type weather patterns. There must be consistency across a map. There must be consistency from map to map. And there must be consistency relative to all meteorological variables, not just the pressure pattern. Additional guidelines for achieving the needed consistency will be presented in a future report on the conterminous United States weather pattern climatology.

Frequency of occurrence of weather pattern types over the Great Plains is determined by the position of major frontal systems. Figures 6 to 9 show the season variation of the frequency of occurrence. Variations track the north-south movement of the polar front and seasonal cyclonic storm tracks. The position of the polar front and the location of major storm tracks effectively separate the Great Plains into northern and southern regions. The southern region is distinguished by the high frequency of occurrence of the subtropical high (Type 6) and low frequency of occurrence of "north-of-the-front" weather pattern types (Types 1, 2, 3, 8).

The "catch-all" weather pattern type - indeterminate (Type 9) - has a distinct maximum over southwestern Texas during the warm months. A thermal low appears in the sea-level pressure pattern over the high inland desert of northern Mexico during these months. This pattern does not fit weather pattern types based on a moving air mass/cyclone model as in Figure 1. The thermal low is most noticeable during periods of relatively weak pressure gradients such as might be found in Types 1, 5 and 6. The alternation of these types with Type 9 is illustrated in Table 15 for Carlsbad, New Mexico. The percentage of alternation to Type 9 is substantially higher at Carlsbad than at Rapid City (Table 4). It can be shown from Part C of Table 15 that 80% of Type 9 runs that begin at noon came from a run of Types 1, 5 or 6.

TABLE 15. Frequency of Alternation From Weather Pattern Type I (Row) to Weather Pattern Type J (Column) at Carlsbad, New Mexico, as the Percentage of Runs That Change From Type I to Type J

Part A: Midnight to midnight alternation

TYPE I	TYPE J								
	1	2	3	4	5	6	7	8	9
1	0.0	0.6	25.4	11.5	16.6	12.8	16.4	1.0	14.5
2	18.8	0.0	25.0	6.3	6.3	6.3	12.5	0.0	25.0
3	15.4	1.8	0.0	11.8	36.6	5.7	16.1	4.7	7.9
4	26.0	0.4	4.8	0.0	33.2	10.8	6.0	2.8	16.0
5	35.1	0.7	4.8	16.9	0.0	10.0	7.8	4.1	19.7
6	35.2	0.4	14.1	5.7	11.9	0.0	16.7	0.9	13.2
7	25.7	0.4	14.5	7.4	26.4	10.8	0.0	4.5	9.7
8	25.0	0.0	15.6	10.9	18.8	4.7	17.2	0.0	7.8
9	26.7	0.3	7.8	12.8	25.0	12.5	11.8	2.0	0.0
RUNS	524	16	279	250	461	227	269	64	296

Part B: Noon to noon alternation

TYPE I	TYPE J								
	1	2	3	4	5	6	7	8	9
1	0.0	1.0	25.8	11.8	16.7	6.6	21.2	1.0	14.8
2	29.6	0.0	25.9	7.4	11.1	0.0	14.8	0.0	11.1
3	14.2	1.9	0.0	11.3	37.2	5.2	20.4	1.0	8.4
4	25.8	0.3	6.2	0.0	38.1	5.5	7.2	2.1	13.7
5	26.7	1.4	6.9	21.6	0.0	4.7	14.5	3.5	19.6
6	28.6	0.0	12.7	9.5	11.9	0.0	15.9	2.4	19.0
7	28.0	1.5	20.1	8.2	28.3	3.5	0.0	2.0	8.2
8	11.4	0.0	20.5	9.1	20.5	6.8	29.5	0.0	2.3
9	28.9	1.0	9.9	14.6	19.0	8.2	16.0	1.0	0.0
RUNS	485	27	309	291	490	126	343	44	294

TABLE 15 (continued)

Part C: Midnight to noon alternation

TYPE I	1	2	3	4	TYPE J 5	6	7	8	9
1	0.0	1.8	23.0	10.6	15.0	7.9	18.7	1.8	20.1
2	6.7	0.0	20.0	0.0	13.3	6.7	40.0	0.0	13.3
3	17.7	2.5	0.0	16.9	27.4	4.2	22.8	1.3	7.2
4	13.9	0.0	5.6	0.0	46.8	4.2	9.3	1.9	18.5
5	25.8	1.0	4.2	26.0	0.0	4.4	14.3	2.9	20.3
6	28.7	0.0	7.0	6.1	16.8	0.0	18.9	2.4	18.9
7	26.3	1.7	15.3	12.3	26.7	3.4	0.0	3.4	10.6
8	17.2	0.0	21.9	15.6	14.1	0.0	29.7	0.0	1.6
9	26.4	1.0	10.2	15.8	22.4	6.6	14.5	2.0	0.0
RUNS	508	15	237	216	384	328	236	64	303

Part D: Noon to midnight alternation

TYPE I	1	2	3	4	TYPE J 5	6	7	8	9
1	0.0	0.0	27.3	6.1	10.8	23.1	15.2	2.0	15.5
2	15.4	0.0	26.9	3.8	23.1	3.8	11.5	11.5	3.8
3	13.7	1.2	0.0	16.9	26.6	5.6	22.2	4.0	9.3
4	24.8	0.3	2.6	0.0	41.9	10.6	4.8	1.9	12.9
5	29.6	1.1	4.2	20.0	0.0	12.7	10.0	3.1	19.2
6	47.6	0.0	7.6	9.5	12.4	0.0	10.5	1.0	11.4
7	24.3	1.2	12.0	6.4	21.3	18.4	0.0	5.0	11.1
8	28.3	0.0	13.0	8.7	21.7	10.9	8.7	0.0	8.7
9	32.5	0.7	10.5	9.5	16.3	20.3	9.2	0.7	0.0
RUNS	407	26	248	310	449	105	342	46	295

Further, from Part D of Table 15, 78% of runs of Types 1, 5 and 6 that began at midnight came from a run of Type 9.

Nearly all weather pattern types show a large variability in their year-to-year frequency of occurrence. As shown in Figure 10, the variability is highest for the least frequently occurring weather pattern types (2, 6, 8 and 9). For most of the stations analyzed, the interannual variability shows no definite trend over the 10-year period of study. However, Type 9 shows a trend towards lower frequency of occurrence (see Figures 11 and 12 for example). This could be real or it could be the result of improving discrimination of weather pattern types as the analysts of the weather maps gained experience.

WIND REGIME

The wind regimes associated with various weather patterns were examined for 37 stations or periods of record. Tables 6 through 12 give some of the statistics determined for each weather pattern type. A 12-hour mean centered on the map time of the hourly wind speeds (Table 7) results in an overall mean wind speed for a weather pattern type that has a lower standard deviation than the mean of the map-time speeds (Table 6).

Resultant wind directions, as determined from Tables 8 and 9, fit the synoptic model fairly well. Departures from the expected synoptic model directions may be due to local topography or to the mean position of major air masses. For example, Types 5 and 6 winds at most locations have a large southerly (from the south) component but may have either a small westerly or easterly component (see Tables 8 and 9). Another useful aspect of Tables 8 and 9 is that the resultant wind speed (square root of sum of squared speeds) along with the scalar mean speed (Table 7) provides a measure of the variability of wind direction:

$$\sigma_{\theta} = \sin^{-1} \sqrt{1 - R/V}$$

where R is the resultant speed and V is the scalar mean speed. Low values of R imply high directional variability.

Anemometer height changes at National Weather Service stations during the study period were usually accompanied by a move from rooftop to ground mast. The change in exposure and surrounding surface roughness made estimates of the shear of the long-term mean wind from mean wind speeds at the two anemometer heights highly unreliable. At those stations at which the power law shear exponent was a reasonable value, substantial differences between weather pattern types were noted. These differences may be ascribed to surface roughness varying by direction and to the thermal stability associated with the weather pattern.

Stratification by weather pattern type provides some discrimination of different wind regimes. The very simple student's t -test showed (Table 13) that the mean wind speeds (Table 7) are from different sample populations with greater than 75% confidence for two-thirds of the possible pairs of weather pattern types. Even so, the differences in mean wind speed between weather pattern types are relatively small (less than 1 m/s, usually). These results indicate that at Great Plains locations mean wind speed is not a good indicator of weather pattern type. Also, the use of a scalar indicator, such as the mean speed, omits the directional character of the wind from the test for a difference between weather pattern type. An inherent shortcoming of the stratification by weather pattern type is that the intensity of the pressure gradient that drives the large-scale synoptic wind field is not parameterized. Examination of Table 6 or 7 shows that Type 8, which occurs near the center of a cyclonic storm, has the highest mean speeds and mean maximum speeds for more than 80% of the stations analyzed. Type 8 is also most likely associated with the strongest pressure gradients among the various weather pattern types.

Weather pattern typing is a useful tool for identifying the major weather patterns that give rise to the wind regime at a site. However, the mean wind speed is not a highly reliable discriminator between weather pattern types.

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