THE USEFUL POTENTIAL OF USING EXISTING DATA TO UNIQUELY IDENTIFY PREDICTABLE WIND EVENTS AND REGIMES - PART I

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ABSTRACT

Correlations between standard meteorological data and wind power generation potential have been developed. Combined with appropriate wind forecasts, these correlations can be useful to load dispatchers to supplement conventional energy sources. Hourly wind data were analyzed for four sites, each exhibiting a unique physiography. These sites are Amarillo, Texas; Ludington, Michigan; Montauk Point, New York and San Gorgonio, California. Synoptic weather maps and tables are presented to illustrate various wind 'regimes' at these sites.

INTRODUCTION

Pacific Northwest Laboratory (PNL) undertook a wind forecast verification study using bivariate time-series analyses. As a consequence of that effort, time-series plots of hourly wind speed and direction were generated. Site specific structures in the wind patterns with respect to time were noted. It was recognized that a valuable tool for the forecasting of wind energy could be produced if the observed wind structures could be correlated with synoptic, subsynoptic or mesoscale weather patterns.

A contract was awarded to Murray and Trettel, Incorporated (M/T) to address the potential use of conventional meteorological data to forecast the wind at four potential wind generation sites.

The sites to be investigated were: San Gorgonio Pass, CA (SAG); Amarillo, TX (AMA); Montauk Point, NY (MTP); and, Ludington, MI (LDM).

DATA

The data used in this study came from three (3) sources:

Pacific Northwest Laboratory (PNL) furnished hourly averaged wind speed and direction time-series plots by month for the year 1979. They also furnished speed and direction data in tabular form. The hourly data were based upon measurements taken at two (2) minute intervals.

The National Climatic Center in Asheville, NC (NCC) furnished microfilm products, including analyses of surface, 850, 700, 500 mbs and winds aloft. They were NCC series MF489, MF494 and MF915.

Murray and Trettel, Inc. (M/T) had numerous in-house products available including adiabatic diagrams for Green Bay, WI (GRB) and synoptic sectionals of portions of the USA. In addition the M/T files of the Daily Weather Maps Weekly Series were used extensively particularly in the Booz-Allen classifications.

GENERAL PROCEDURE

Although there was necessarily some variation in the procedure due to the location and topography of the four (4) sites there was a general procedure that was used at all the sites.

Data Stratification

The data were tabulated from computer printout according to wind speed, hours of duration of certain wind speeds (7, 10 and 15 mps), maximum speed for the day along with direction and time of occurrence.

The data were stratified based on the following reasoning. The critical wind speed chosen was 7 mps (14 knots). This is just above the 6.26 mps that activates the MOD-2 generator. The number of days for each month that had an hourly wind speed equal to or greater than 7 mps was logged. The number of consecutive hours of speeds equal to or greater than 7 mps was also logged. This was further stratified into three types:

<u>Type 1</u>: less than three (3) consecutive hours of wind speeds equal to or greater than 7 mps.

<u>Type 2</u>: 3-7 consecutive hours of wind speeds equal to or greater than 7 mps.

<u>Type 3</u>: 8 or more consecutive hours of wind speeds equal to or greater than 7 mps.

The rationale for this breakdown was based upon M/T experience in working with electric load dispatchers since 1959. Type 1 would not be a long enough period to produce useful generation; Type 3 would be long enough to produce useful generation; Type 2 was considered a marginal situation.

The data are also being analyzed for 10 mps and 15 mps thresholds and will be included in the final report.

Booz-Allen (B/A) Classification

Each day of the year was classified as to weather pattern using the B/A classification for both ground level surface and 500 mbs. A copy of these classifications is found in Appendix A.

The B/A scheme was looked at as only a preliminary step. The advantage of the B/A classification is that it gives a quick and easy description of a synoptic map. However, it has the disadvantage that pressure gradients are not directly specified. This is important in studying wind speeds. In addition, the classification is subject to the interpretation of the individual meteorologist. For example B/A Surface 24 is Pretrough, 29 is Postridge; at 500 mbs 9 is Pretrough, 15 is Postridge.

The B/A index was tabulated for each day rather than just certain selected situations. There were two reasons for this: (1) there was interest not only in the occurrence of strong winds but also periods of light, persistent winds when wind turbine operations would be at a minimum, and (2) it was more efficient to accomplish the entire task at one time. This classification was accomplished using the Daily Weather Map Weekly Series for all four sites.

850 MB Wind Data

The 850 mb wind speeds and directions were tabulated for each day and logged along with the data described above. There was some disadvantage to this because of the difference in elevation of the four sites. However, the 850 mb data and other selected levels (UW/US North America-TTAA) come in on the 604 teletype circuit earlier (1255Z) than the complete sounding. Furthermore using this selected level data would enable the meteorologist to make his forecast without waiting for the complete 850 mb chart on the DIFAX circuit (1433Z). This is a difference of almost two hours - a significant time period in load forecasting.

The radiosonde stations used were Amarillo, TX (363); Green Bay, WI (645) and Flint, MI (637) for Ludington, MI (LDM); New York (486) for Montauk Point (MTP); and Vandenberg AFB (393) and Las Vegas, NV (387) for San Gorgonio, CA (SAG).

Second Standard Level Wind Data

As the data logging progressed and some preliminary analysis was begun, the difference in elevation of the various sites led to the conclusion that the wind data at the second standard level should be examined. This would overcome the disadvantage of the 850 mb data mentioned above. But it should also be noted that this information is not available until a later time in the form of UJ1 PPBB on the 604 line (starting at 1356Z) and even later on the DIFAX circuit (1549Z).

The same stations were used as indicated with the 850 mb data.

Pressure Gradient Analysis

The pressure gradients were measured across the selected sites in two ways. The first method simply logged the pressure difference between two representative stations. For example, in the case of San Gorgonio the pressure difference between Los Angeles (LAX) and Las Vegas (LAS) was used. This worked very well particularly for the summer months because the changes in the pressure patterns were minor. However, it became apparent that although this method worked well for San Gorgonio, it did not work well for Montauk Point. A second method used the synoptic surface maps and measured the pressure gradient across the site for a distance of 150 nautical miles (75 miles on either side). The direction perpendicular to the gradient was also logged. It was felt that the direction of the gradient would be important due to local effects. This method worked better for the other three sites because they were affected by various pressure systems moving across the area.

SITE 1: MONTAUK POINT, NY (MTP)

Data Stratification

The hourly wind data furnished by PNL were analyzed and divided into Types 1, 2 and 3 described above. Particular emphasis was placed upon a speed threshold of 7 mps because of its impact on the MOD-2 wind turbine and load generation. These data are tabulated in Table 1. In 1979 there was a total of 3,436 hours of winds speeds equal to or greater than 7 mps. This represents 41 percent of the possible total hours. The percentages ranged from a maximum of 68 percent in January to a minimum of 18 percent in July. It was not surprising that the cold weather season (Dec-Feb) showed the highest values (average of 65 percent) with the lowest values (average 22 percent) in the warm months (June through September).

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Table 1. STRATIFICATION OF WIND SPEEDS AT
MONTAUK POINT, NY - 1979 - TYPES 1, 2 AND 3

	HOURS				DAYS										
Mon	Avail Data	≥7 mps obs	poss	%	Avail Data	Type 1 No.	%	Type 2 No.	%	Type 3 No.	%	None ≥7 No.	%	Msg
J	652	442	744	68	28	3	11	2	7	23	82	0	0	3
F	672	437	672	65	28	0	0	5	18	21	75	2	7	0
M	744	277	744	37	31	6	19	5	16	14	45	6	19	0
A	720	293	720	41	30	4	13	6	20	15	50	5	17	0
M	744	299	744	40	31	4	13	7	23	17	55	3	10	0
J	72C	174	720	24	30	2	7	6	20	7	23	15	50	0
J	427	77	744	18	19	3	16	2	11	4	21	10	53	12
A	744	154	744	21	24	6	25	2	8	8	33	8	33	7
S	720	188	720	26	30	4	13	7	23	9	30	10	33	0
O	744	311	744	42	31	5	16	3	10	19	61	4	13	0
N	720	328	720	46	30	3	10	3	10	17	57	7	23	0
D	744	456	744	61	31	2	6	3	10	23	74	3	10	0
TOT	8351	3436	8760	41	343	42	12	51	15	177	52	73	21	22

Although the total hours of wind speeds strong enough to activate a MOD-2 generator was of interest it was felt that the number of consecutive hours of speeds equal to or greater than 7 mps would be more significant. The data were therefore further stratified into Type 1, 2 and 3 'days' (See Table 1). The Type 3 day (speeds equal to or greater than 7 mps for 8 or more consecutive hours) were of particular interest. The values ranged from an average high of 22 days (77 percent) in the period December through February to an average low of 7 days (27 percent) in the four month period June through September.

This leads to the conclusion that wind speeds at MTP were strong enough to activate a MOD-2 generator an average of 52 percent of the days in 1979 with values ranging from 82 percent in January to 21 percent in July. Wind power could have a significant impact on the cold weather heating load but minimal impact on the summer air conditioning requirements.

Booz-Allen (B/A) Classification

The B/A classification was poorly correlated with the Wind Types and was not considered a highly useful tool in this application except in a general way. As discussed earlier this was not too surprising due to the lack of direct consideration of pressure gradients.

An example of a Type 1 day (light winds) occurred on 15 February and is shown in Figures 1 and 2. Note the weak gradient due to the ridge of high pressure (B/A type = 33, post inverted ridge). The 500 mb chart shows strong NW flow (B/A type = 14, pre-ridge). These maps are good examples of the need for judgment by the forecaster. The B/A surface type could have been 33, 34 or 35; the 500 mb could have been 10 or 14.

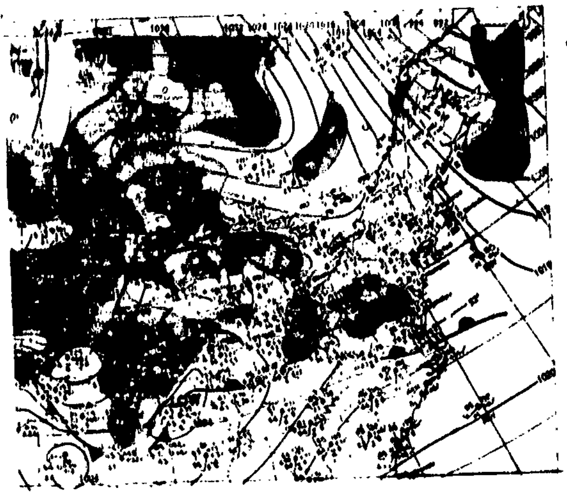

Figure 1. 15 FEBRUARY 1979
SURFACE MAP AT 1200Z (B/A=33)

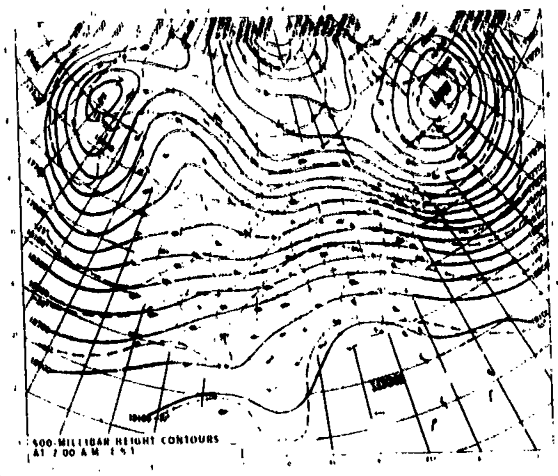

Figure 2. 15 FEBRUARY 1979
500 MB CHART AT 1200Z (B/A=14)

An example of Type 3 (strong winds) occurred on 1 February and is shown in Figures 3 and 4. Surface B/A = 3, (deep closed low-postfrontal); 500 mb B/A = 4 (deep closed low-post trough)

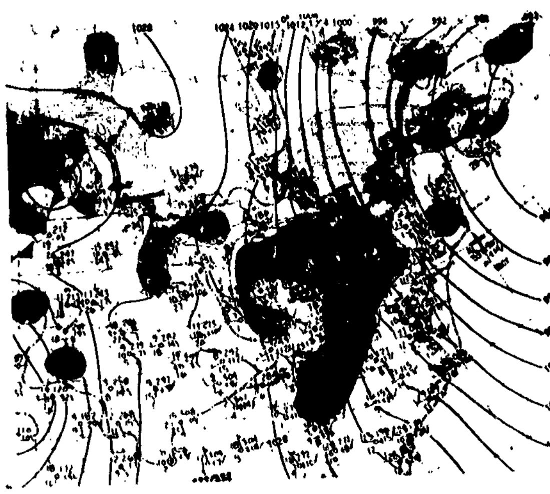

Figure 3. 1 FEPRUARY 1979
SURFACE MAP AT 1200Z (B/A=3)

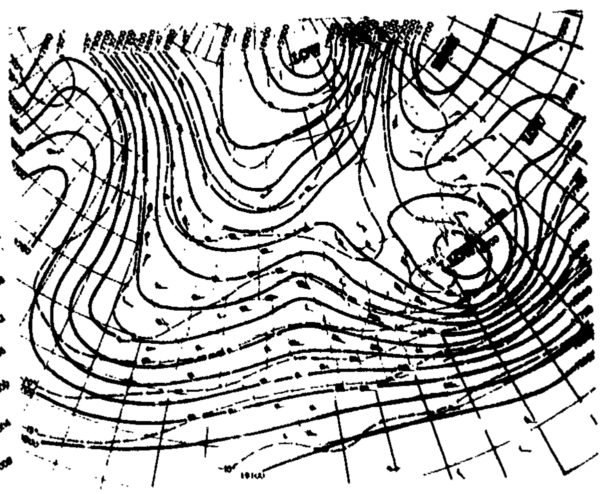

Figure 4. 1 FEBRUARY 1979
500 MB CHART AT 1200Z (B/A=4)

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850 MB Wind Data

The 850 mb wind data at New York were compared with the PNL data from MTP. In particular the 850 mb speed was analyzed and compared with the maximum hourly wind speed in the succeeding twelve hours. These data are presented in Table 2.

Table 2. MAXIMUM HOURLY WIND SPEED AT MONTAUK POINT IN SUCCEEDING 12 HOURS AS A PERCENTAGE OF 850 MB WIND SPEED AT NEW YORK (486)

MONTH	MONTHLY AVERAGE	DISTRIBUTION BY DIRECTION							
		S	SW	W	NW	N	NE	E	SE
Jan	101	58	87	106	135	101	--	--	--
Feb	87	90	--	68	96	69	--	--	90
Mar	90	43	93	129	104	83	64	--	68
Apr	89	74	104	92	86	70	--	--	--
May	107	107	104	108	120	--	100	133	100
Jun	123	113	170	127	77	110	--	--	--
Jul	102	--	71	130	93	240	--	--	--
Aug	93	--	83	95	92	111	--	108	--
Sep	114	109	130	103	125	109	--	180	140
Oct	108	82	120	100	200	160	--	--	--
Nov	105	--	61	92	128	84	--	350	--
Dec	97	88	63	67	106	155	--	--	--
Avg.	101	85	99	101	114	117	82	193	100

The maximum hourly wind speed at MTP for 1979 was 101 percent of the average 850 mb speed for the year. The values ranged from 123 percent in June to 87 percent in February. The distribution of the comparison by months and direction was also tabulated. However, these values should be viewed only as guides because of the size of this sample. It appears that the largest difference between the observed maximum hourly wind speed and the 850 mb speed occurs with a NW and N wind (E was discounted because of the small sample and the unusually high single value in November).

The conclusion is that the 850 mb wind speed at 1200Z or 0000Z is a good first approximation of the maximum hourly wind in the succeeding twelve hours.

SITE 2: LUDINGTON, MI (LDM)

Data Stratification

The data for LDM were stratified in the same manner as Montauk Point. The data are presented in Table 3.

Table 3. STRATIFICATION OF WIND SPEEDS AT LUDINGTON, MI - 1979 - TYPES 1, 2 AND 3

	HOURS				DAYS (1200Z-1200Z)									
	Avail	≥ 7 mps			Avail	Type 1		Type 2		Type 3		None≥7		
Mon	Data	obs	poss	%	Data	No.	%	No.	%	No.	%	No.	%	Msg
J	744	509	744	68	31	0	0	4	13	25	81	2	6	0
F	633	348	672	55	25	1	4	5	25	18	72	1	4	3
M	672	407	744	61	27	0	0	7	26	19	70	1	4	4
A	529	232	720	44	20	0	0	9	45	9	45	2	10	10
M	744	333	744	45	31	3	10	6	19	19	61	3	10	0
J	720	349	720	49	30	5	17	5	17	20	67	0	0	0
J	744	181	744	24	31	9	29	6	19	9	29	7	23	0
A	744	298	744	40	31	4	13	9	29	17	55	1	3	0
S	720	399	720	55	30	3	10	6	20	20	67	1	3	0
O	744	451	744	61	31	2	7	4	13	25	81	0	0	0
N	0	---	720											
D	0	---	744											

The same general pattern as observed at MTP was also noted at LDM. The maximum percentage (hours) of Type 3 winds occurred in January (68 percent) and the minimum in July (24 percent). The average for the ten month period was 50 percent but would have been higher if data for November and December had been included.

Type 3 winds ranged from a maximum of 25 days (81 percent) in January and October to a minimum of 9 days in July (29 percent).

Booz-Allen (B/A) Classification

As in the case of MTP the B/A classification was useful in only a limited way. The moving synoptic systems often cause the B/A types to change rather rapidly as the pressure systems move across the location.

Two synoptic situations are shown. The first example is a Type 1 day (light winds) shown in Figures 5 and 6. The B/A classifications for 10 July are: surface = 35 (flat pressure area); 500 mb = 10 (meridional trough-posttrough).

The second example is a Type 3 day (strong, persistent winds) shown in Figures 7 and 8. The B/A classifications for 6 February 1979 are: surface = 14 (open wave cyclone moving SE or E, center S, pretrough); 500 mb = 15 (meridional ridge, portridge).

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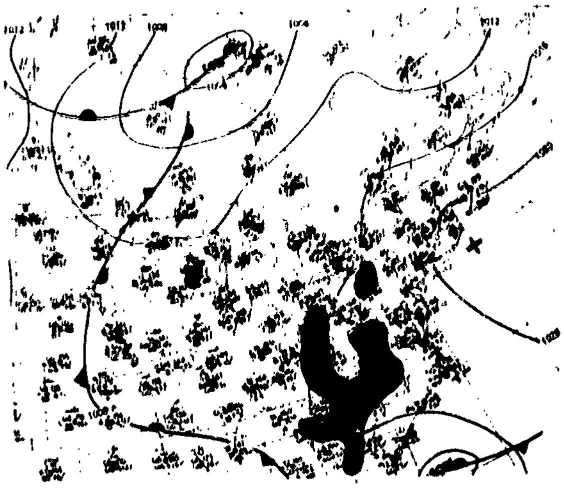

Figure 5. 10 JULY 1979
SURFACE MAP AT 1200Z (B/A=35)

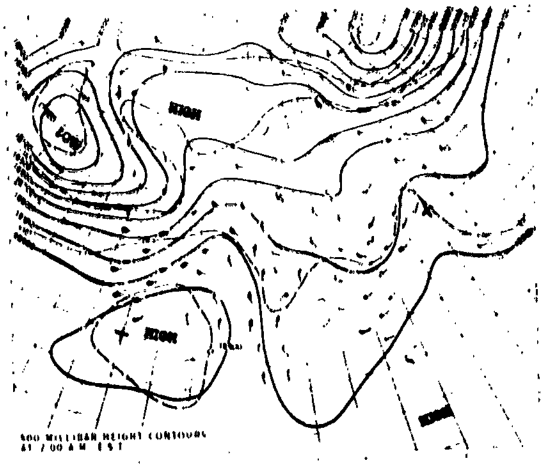

Figure 6. 10 JULY 1979
500 MB CHART AT 1200Z (B/A=10)

Figure 7. 6 FEBRUARY 1979
SURFACE MAP AT 1200Z (B/A=14)

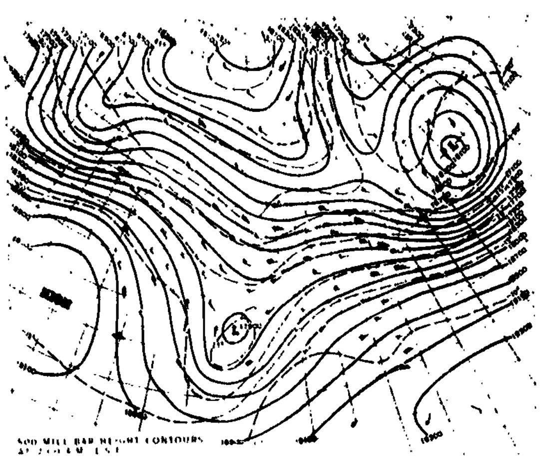

Figure 8. 6 FEBRUARY 1979
500 MB CHART AT 1200Z (B/A=15)

Stagnant high pressure systems are most favorable for Type 1; strong, moving systems with shifting winds favor Type 3.

850 MB Wind Data

The GRB 850 mb wind speed at 1200Z was logged for each day. The PNL wind data for LDM was classified for each day as Type 1, 2 or 3. The results were tabulated and are presented as percentages of occurrence in Table 4.

Table 4. 12Z 850 MBS GRB WIND SPEED (KNOTS)
VS LUDINGTON MI WIND TYPE

WIND SPEED 12Z GRB 850 mbs	PERCENT OCCURRENCE Type 1	Type 2	Type 3	No. of Cases
0- 2 kts	--	--	--	
3- 7	27	35	38	55
8-12	20	33	47	60
13-17	12	10	79	61
18-22	5	18	77	44
23-27	16	16	68	19
28-32	0	8	92	12
33-37	0	0	100	5
38-42	0	0	100	6
43-47	--	--	--	
			Total:	262

The data indicate that when the GRB 850 mb wind is equal to or greater than 13 knots, a Type 3 day occurs at LDM 80 percent of the time in the following twenty-four (24) hours (1200Z-1200Z). When 850 mb wind is equal to or greater than 23 knots, Type 3 occurs 83 percent of the time; equal to or greater than 28 knots, 96 percent of the time.

The conclusion is that the 850 mb wind at GRB at 1200Z is a good first approximation of the type of wind day that is likely to occur at LDM.

Pressure Gradient Analysis

The pressure gradients on the surface maps in mbs per one hundred fifty (150) nautical miles were measured daily at 1200Z. The pressure difference and the direction of the gradient were logged and compared with the Wind Type (1, 2 or 3). There were 282 cases (instead of 365) in this analysis due to missing data. (The LDM data for November and December 1979 were missing entirely. November and December 1978 data have been obtained and will be included in the final report in order to complete an entire year.)

Table 5 shows the tabulation of the number of occurrences for each pressure difference and the percentage of the total for each type of day. Note that when the pressure gradient is equal to or greater than 3 mbs, a Type 3 day occurs 82 percent of the time; equal to or greater than 4 mbs, 87 percent; equal to or greater than 5 mbs, 92 percent.

Table 5. LUDINGTON MI PRESSURE GRADIENT VS SURFACE WIND

ALL DAYS

TYPE		PRESSURE GRADIENT-MBS 0	1	2	3	4	5	6
1	No. of Occurrences	-	16	14	7	6		
	% of Occurrences	-	38	21	13	11	0	0
2	No. of Occurrences	-	14	23	9	5	3	2
	% of Occurrences	-	35	34	16	9	12	5
3	No. of Occurrences	-	11	30	40	44	23	36
	% of Occurrences	-	28	45	71	80	89	95

GRADIENT 010-090°

TYPE		PRESSURE GRADIENT-MBS 0	1	2	3	4	5	6
1	No. of Occurrences	-	1	2	2	2		
	% of Occurrences	-	11	17	15	15		
2	No. of Occurrences	-	6	6	3	3	2	1
	% of Occurrences	-	67	50	23	23	33	13
3	No. of Occurrences	-	2	4	8	8	4	7
	% of Occurrences	-	22	33	62	62	67	88

GRADIENT 100-180°

TYPE		PRESSURE GRADIENT-MBS 0	1	2	3	4	5	6
1	No. of Occurrences	-	3	1	2	2		
	% of Occurrences	-	30	8	11	18		
2	No. of Occurrences	-	3	8	5	1		
	% of Occurrences	-	30	62	26	9		
3	No. of Occurrences	-	4	4	12	8	6	11
	% of Occurrences	-	40	31	63	73	100	100

GRADIENT 190-270°

TYPE		PRESSURE GRADIENT-MBS 0	1	2	3	4	5	6
1	No. of Occurrences	-	10	3	3			
	% of Occurrences	-	56	14	19			
2	No. of Occurrences	-	3	6	2			1
	% of Occurrences	-	17	29	13			25
3	No. of Occurrences	-	5	12	11	13	8	4
	% of Occurrences	-	28	57	69	100	100	75

GRADIENT 280-360°

TYPE		PRESSURE GRADIENT-MBS 0	1	2	3	4	5	6
1	No. of Occurrences	-	2	3	0	2		
	% of Occurrences	-	67	17		11		
2	No. of Occurrences	-	1	5	3	1	1	
	% of Occurrences	-	33	28	30	6	14	
3	No. of Occurrences	-		10	7	15	6	13
	% of Occurrences	-		56	70	83	86	100

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These data were further subdivided into quadrants to examine local affects caused by Lake Michigan. The results are tabulated in Table 5. Note that the percentage of Type 3 days decreases (66 vs 82) for the 010-090 quadrant (due to frictional effect) while the 190-270 (86 vs 82) and 280-360 (85 vs 82) quadrants have an increase (due to less friction over Lake Michigan).

The conclusion is that when a pressure gradient of equal to or greater than 3 mbs exists at 1200Z across LDM a Type 3 day is expected to occur at least 66 percent of the time and more likely to occur 82-86 percent of the time.

SITE 3: AMARILLO, TX (AMA)

The PNL data for AMA were stratified and classified in a manner similar to MTP and LDM. In addition the 850 mb wind speed at 1200Z was tabulated and compared with the number of consecutive hours (up to 24 hours) of PNL wind speeds equal to or greater than 7 mps. Figure 9 shows this data.

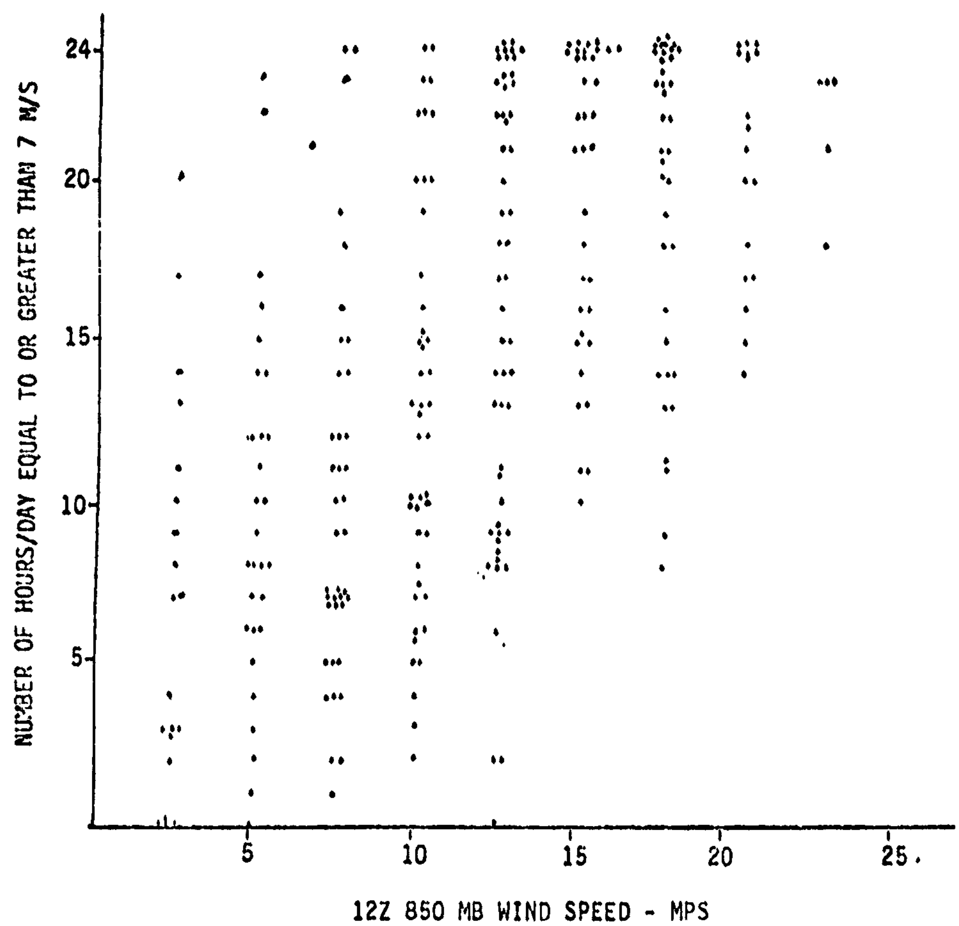

Figure 9. 850 MB WIND SPEED AT 1200Z VS THE NUMBER OF CONSECUTIVE HOURS OF WINDS EQUAL TO OR GREATER THAN 7 MPS AMARILLO, TX (1979)

Although there is a wide scatter of the tabulation there is a definite trend indicated. The conclusion is that the stronger the wind at 850 mbs at 1200 the greater number of consecutive hours of wind speeds equal to or greater than 7 mps.

An example of a Type 1 situation (light winds) is shown in Figures 10 and 11 for 12 February 1979. The surface B/A = 35 (flat pressure area); the 500 mb B/A = 14 (meridional ridge, proridge). An example of a Type 3 situation (strong persistent winds) is shown in Figures 12 and 13 for 20 February 1979. The surface B/A = 24 (meridional trough, pretrough); the 500 mb B/A = 9 (meridional trough, pretrough). The 20 February situation was one of a series of systems moving across the AMA area. Type 3 winds persisted for ninety-six (96) consecutive hours from 19 February through 22 February.

Figure 10. 12 FEBRUARY 1979
SURFACE MAP AT 1200Z (B/A=35)

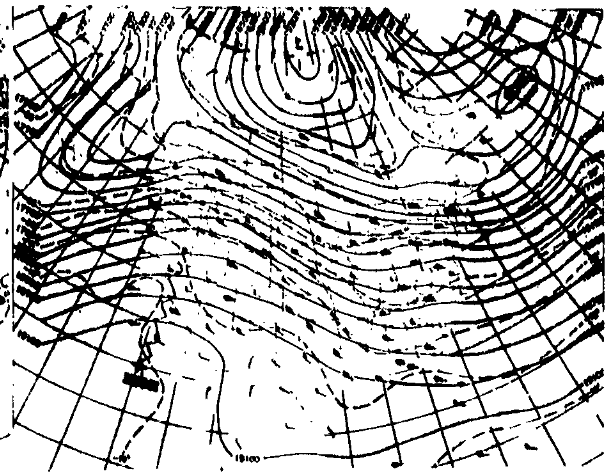

Figure 11. 12 FEBRUARY 1979
500 MB CHART AT 1200Z (B/A=14)

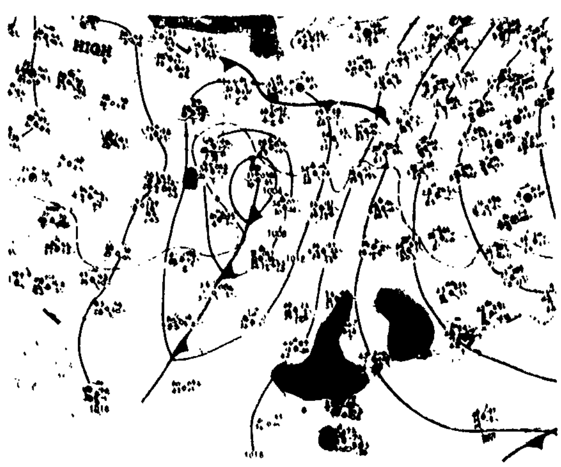

Figure 12. 20 FEBRUARY 1979
SURFACE MAP AT 1200Z (B/A=24)

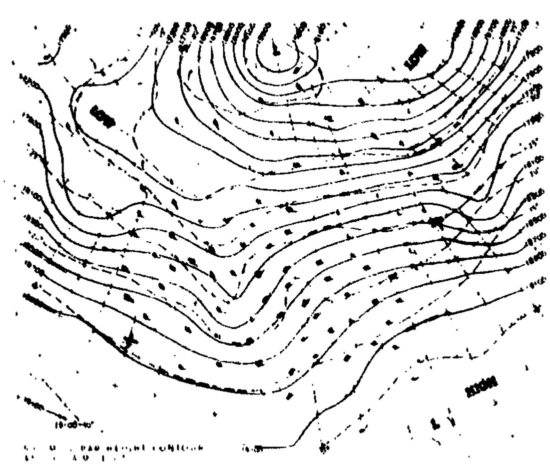

Figure 13. 20 FEBRUARY 1979
500 MB CHART AT 1200Z (B/A=9)

The conclusion is that a long wave trough over the Rocky Mountains with a series of short wave troughs at 500 mbs along with associated surface weather systems is a favorable pattern for Type 3 days. A weak ridge over the Rocky Mountains is less favorable.

SITE 4: SAN GORGONIO, CA (SAG)

This site is discussed in detail in Part 2 of this report. The B/A types had high degree correlation with both Type 1 and Type 3 days.

CONCLUSIONS

Montauk Point, NY (MTP)

In 1979 there was a total of 3,436 hours of wind speeds equal to or greater than 7 mps. This represents 41 percent of the hours observed.

Type 3 days occurred 52 percent of the days in 1979 ranging from a high value of 82 percent in January to a low value of 21 percent in July.

The 850 mb wind speed is a good first approximation of the maximum hourly wind in the next 12 hours.

Ludington, MI (LDM)

When the GRB 850 mb wind is equal to or greater than 13 knots a Type 3 day occurs at LDM 80 percent of the time in the following 24 hours.

When a pressure gradient equal to or greater than 3 mbs (across 150 nautical miles) exists at 1200Z across LDM a Type 3 day is expected to occur at least 66 percent of the time and more likely to occur 82-86 percent of the time.

Amarillo, TX (AMA)

The stronger the wind at 850 mb the greater the number of consecutive hours of wind speeds equal to or greater than 7 mps.

A long wave trough over the Rocky Mountains with a series of short wave troughs at 500 mbs with associated surface weather systems is a favorable pattern for Type 3 days. A weak ridge over the Rocky Mountains is less favorable.

San Gorgonio, CA (SAG)

The B/A types had a high degree of correlation with Type 1 and Type 3 days.

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APPENDIX — The Booz-Allen Surface Types

Type No.	Description
	1. Deep Closed Low (deepening or mature cyclone)
	a. Center North
1	(1) Advance Zone
2	(2) Prefrontal and frontal (occulsion or warm front) (or trough)
3	(3) Postfrontal (or trough) (cold front or occlusion)
4	(4) Warm sector
5	(5) Prefrontal and frontal (cold)
	b. Center South
6	(1) Advance Zone
7	(2) Pretrough
8	(3) Posttrough
	2. Open Wave Cyclone Moving SE or E
	a. Center North
9	(1) Advance Zone
10	(2) Prefrontal (warm)
11	(3) Warm sector
12	(4) Prefrontal and frontal (cold)
13	(5) Postfrontal (cold)
	b. Center South
14	(1) Pretrough
15	(2) Posttrough
	3. Open Wave Cyclone Moving NE
	a. Center North
16	(1) Frontal (warm)
17	(2) Warm sector
18	(3) Prefrontal and frontal (cold)
19	(4) Postfrontal (cold)
	b. Center South
20	(1) Advance Zone
21	(2) Pretrough, warm front zone
22	(3) Posttrough
23	(4) Warm sector
	4. Meridional Trough (N-S or tilted)
24	a. Pretrough
25	b. Posttrough
26	c. Trough or frontal zone
	5. Inverted Trough
27	a. Pretrough
28	b. Posttrough
	6. Ridge, or High, Center South (or same latitude)
29	a. Preridge
30	b. Postridge

The Booz-Allen Surface Types (Continued)

Type No.	Description
	7. High, Center North (or same latitude)
31	a. Preinverted ridge
32	b. Center
33	c. Postinverted ridge
34	d. E-W gradient
	8. Flat Pressure Area
35	Cols or other areas (except high centers) where wind is indeterminate.

The Booz-Allen 500-millibars Types

Type No.	Description
	1. Deep Closed Low
	a. Center North
1	(1) Pretrough
2	(2) Posttrough
	b. Center South
3	(1) Pretrough
4	(2) Posttrough
	2. Weak Closed Low
	a. Center North
5	(1) Pretrough
6	(2) Posttrough
	b. Center South
7	(1) Pretrough
8	(2) Posttrough
	3. Meridional Trough (N-S or tilted)(including transitional)
9	a. Pretrough
10	b. Posttrough
	4. Basically Zonal
11	a. Westerly flow
12	b. Preminor trough
13	c. Postminor trough
	5. Meridional Ridge
14	a. Preridge
15	b. Postridge
	6. High, Center North (or same latitude)
16	a. Preinverted ridge
17	b. Center
18	c. Postinverted ridge
19	d. E-W gradient
	7. Flat Pressure Area
20	Cols or other transitional areas (except highs) where wind is indeterminate and there is no convergence.