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DEPARTMENT OF TRANSPORT
METEOROLOGICAL BRANCH

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THE DIRECTION AND SPEED OF THE SURFACE WIND AT WINNIPEG

BY

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ABSTRACT

The numbers of hourly occurrences of the stronger wind speeds at Winnipeg were tabulated by months and by direction. 78 percent of the occurrences were with the directions of NW, NNW, N, NNE, SSE and S.

The gradient and geostrophic winds were calculated from surface synoptic charts and compared to the recorded surface gusts. The possible effect of the preference for direction is applied to the gust speed.

A method of forecasting the direction, mean speed, and peak gust speed of the surface wind is developed together with two formulae and a check list for its application.

LA DIRECTION ET LA DISPERSION DU VENT EN SURFACE À WINNIPEG

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RÉSUMÉ

L'auteur a mis en tableaux par mois et par direction les nombres de cas de vents forts par heure à Winnipeg. Soixante-dix-huit p. 100 des cas étaient dans les directions N.-O., N.-N.-O., N., N.-N.-E., S.-S.-E. et S.

Les vents de gradient et les vents géostrophiques ont été calculés à l'aide de cartes synoptiques en surface et comparés aux rafales en surface enregistrées. L'effet possible de la préférence de direction est appliqué à la vitesse des rafales.

L'auteur expose une méthode de prévision de la direction, de la vitesse moyenne et de la vitesse de rafale maximale du vent en surface et donne deux formules ainsi qu'une liste pour en vérifier l'application.

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(Manuscript Received July 7, 1966 In Revised Form August 17, 1966)

1. Introduction

The Royal Canadian Air Force at Winnipeg has a requirement for advance knowledge of strong gusty surface winds with the peak gust speed being the most important factor. This study was undertaken in an effort to find a method of forecasting these conditions from prognostic surface charts.

A preliminary study (Appendix A) showed that the directions of NW, NNW, N, NNE, SSE, and S accounted for 78% of the strong wind occurrences.

2. Data

The data used in this study is for the Winnipeg International Airport as taken from:

- those synoptic charts for 1963 with a geostrophic wind speed at Winnipeg in excess of 29 knots (these charts were analyzed by the Meteorologists of the Weather Office);

- the Surface Weather Records for January through December 1963; and,

- the Dines Anemograph charts for January 1 through November 26, 1963. (The instrument was removed from service at 1500Z November 26, 1963).

3. Method and Results

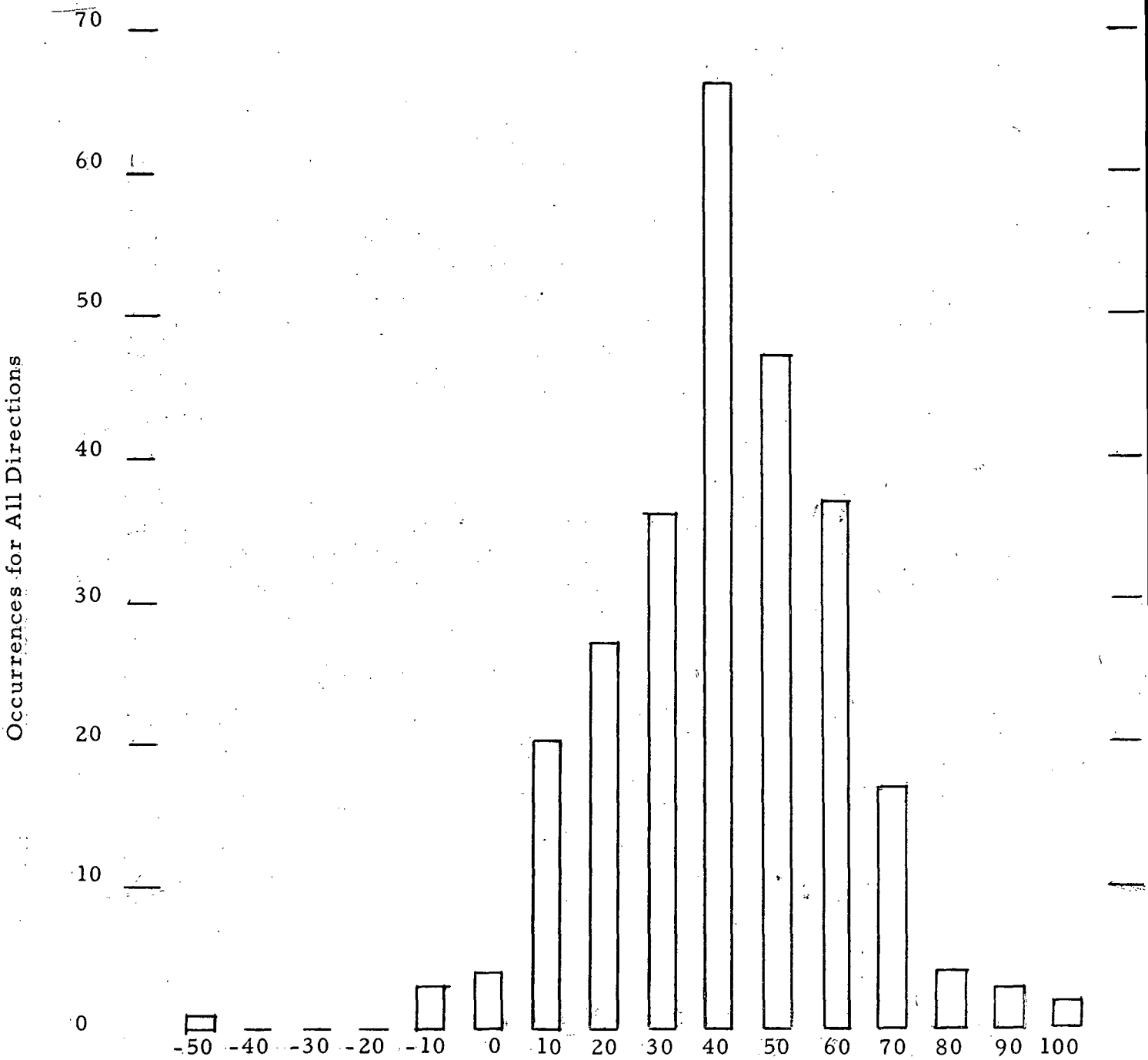
The geostrophic wind direction as abstracted from the synoptic surface charts was compared to the corresponding surface wind direction. In all but 8 of the 267 cases used, the geostrophic wind direction backed by an angle θ to become the surface wind direction. The size of θ varied between -50 and 100 degrees. An assumed backing angle θ_a, which contains the largest number of occurrences within plus or minus 20 degrees was determined for

TABLE 1

The Distribution of Cases by the Angle θ,
where θ is the Angle Between the Actual and Geostrophic Wind Directions.

Geos Wind Dirn	θ, the Angle Between the Actual and Geostrophic Wind Direction and Considered Positive Where the Actual Wind is counter-clockwise from the Geostrophic. -50	-10	0	10	20	30	40	50	60	70	80	90	100	Assumed Backing Angle θ_a (Degrees)	Cos θ_a	Simple Peak Gust Factor
010				1		5	1	3						40	.77	.8
020					1		4		2					40	.77	.8
030				2		3		6		3				50	.64	.6
040							12		6		1			50	.64	.6
050				1		3		8		2				50	.64	.6
060							6	1	11		1			50	.64	.6
070						3		2	1	2				50	.64	.6
080				1			3		3				1	50	.64	.6
090								1		2				50	.64	.6
100														50	.64	.6
110														50	.64	.6
120							1		1					50	.64	.6
130	1	1			2		1					2		40	.77	.8
140			2			1		1						40	.77	.8
150		1		1		1	2							30	.87	.9
160			2		1									30	.87	.9
170				1		3			1					30	.87	.9
180					1		1							30	.87	.9
190		1		4		2	1	2						30	.87	.9
200					4		9							30	.87	.9
210					1	5		4						30	.87	.9
220							11	2	1					40	.77	.8
230						2		6		1	1			50	.64	.6
240						1	2		4					50	.64	.6
250						2		3	1	6		1		50	.64	.6
260				2			1		1		1			50	.64	.6
270								3		1				50	.64	.6
280				1		3		1						40	.77	.8
290					3		2							30	.87	.9
300							1						1	30	.87	.9
310					5		2							30	.87	.9
320						1		2						30	.87	.9
330				4			3		2					30	.87	.9
340					8			2						30	.87	.9
350				2		1			3					40	.77	.8
360					1		3							40	.77	.8
	1	3	4	20	27	36	66	47	37	17	4	3	2	Total: 267 cases		

Figure 1
Occurrences of θ, the Angle Between the Actual and Geostrophic Wind Directions, for All Wind Directions, for 267 Cases of Geostrophic Wind at Winnipeg Greater Than 29 Knots During 1963.



θ, the Angle Between the Actual and Geostrophic Wind Directions and Considered Positive Where the Actual Wind is Counter-clockwise from the Geostrophic.

each geostrophic wind direction. Table 1 shows the distribution of cases by the angles, θ, where θ is the angle between the actual and geostrophic wind directions and considered positive when the actual wind is counter-clockwise from the geostrophic wind direction. Figure 1 is a pictorial description of Table 1.

The gradient wind speeds were calculated from the synoptic charts using the Godson Gradient-Wind Nomogram (1). These speeds were compared with the peak gusts registered on the Dines. Table 2 shows the distribution of the differences between the calculated gradient wind speeds and the corresponding peak Dines gust speeds.

The local topography may have a steering effect on the surface wind. If this is so, then the speeds of the surface winds are possibly related to the angles the isobars make with the topographical features. Thus, the geostrophic wind was multiplied by $\cos \theta_a$ simplified to one significant figure, and the results compared to the peak Dines gust speeds. The distribution of the difference between the calculated wind speeds and the observed peak gust speeds is indicated in Table 2.

The error in prognostic charts of 12 hours or more would be as great as the variation of θ_a from 30 to 50 degrees. Thus, the geostrophic wind for all cases was multiplied by the cosine of 40 degrees and the results compared to the peak gust speeds. The distribution of the difference is indicated in Table 2.

TABLE 2

Distribution of Differences Between Calculated Wind Speeds and Observed Peak Gust Speeds

Calculated		Actual	Range of Error			
			± 3	± 5	± 7	± 9
Gradient Wind	-	Peak Dines	11%	17%	28%	38%
Geostrophic Wind (using $\cos \theta_a$ .9, .8, .6)	-	Peak Dines	26%	44%	57%	70%
Geostrophic Wind (using $\cos \theta_a$ .8)	-	Peak Dines	23%	35%	51%	66%

An attempt was made to introduce stability in the surface layer as a factor in the speed of the maximum gust. The results were inconclusive. However, in a southerly flow peak gusts were greater when the surface layer was unstable.

The mean wind speeds in relation to certain ranges of peak gust speeds were tabulated in Table 3.

The check list in Appendix B was constructed to provide a systematic method of using the information contained in this paper.

The geostrophic wind is used in this forecast method rather than the gradient wind, because the method is simpler and the results are better.

This paper does not take into account the cases of strong surface gusts when the geostrophic wind speed is less than 30 knots.

TABLE 3

A Comparison of the Peak Dines Gust Speed and the Mean Anemometer Speed for All Directions.

Peak Dines Gust Speed (mph)	Anemometer Mean Speed (mph)	Number of Cases
Greater than 44	33	8
35 - 44	25	55
25 - 34	19	94
Less than 25	13	62

4. Conclusions

The geostrophic wind provided satisfactory results in endeavouring to determine the peak surface wind gust speed and direction at Winnipeg.

The peak gusts occur in a direction which varies from 30 to 40 degrees counter-clockwise from the geostrophic wind direction, and this counter-clockwise variation is dependent upon the direction of the geostrophic wind.

The peak gust speed may be approximated by the product of the geostrophic wind speed and the cosine of the angle between the actual and geostrophic wind directions.

For prognostic surface charts of 12 hours or more, the following formulae apply:

(1) Direction of Gust = Direction of Geostrophic Wind -40

(2) Peak Gust Speed = Geostrophic Wind Speed x Cos 40
$\approx$ 0.8 (Geostrophic Wind Speed)

For short-range forecasts of approximately 3 hours, the check list given in Appendix B should be used to derive a more accurate forecast of peak gust speed and direction.

APPROVED,

J. R. H. Noble,
Director,
Meteorological Branch.

5. Reference

(1) Godson, W. L., 1948: A New Gradient Wind Nomogram. Bull. Amer. Meteor. Soc., 29, 95-100.

APPENDIX A

The Direction of the Stronger Surface Winds at Winnipeg

1. Introduction

The stronger surface winds at Winnipeg generally blow from certain directions and are very unusual from other directions.

This study was undertaken to determine the preferred direction for the stronger winds and to ascertain when strong winds could be anticipated from the less preferred directions.

2. Data

The data for this study were taken from the Surface Weather Record for Winnipeg International Airport for the period January 1961 through December 1963.

3. Method and Results

The hourly reports were searched for occurrences of mean wind speed in excess of 19 miles per hour, and/or gusts in excess of 24 miles per hour. The occurrences were tabulated by month and by direction (16 points). The annual distribution of strong wind occurrences among the 16 directions was calculated. (See Table 1).

Those directions having less than their share of the strong winds, on the basis that a direction shall be said to have an equal share if its percentage of the strong winds is equal to its percentage of all winds, (see Table 2), were called Non-Preferred Directions. A study of the wind from these directions indicated that strong winds for a duration of more than one hour should only be anticipated with a deep low in the vicinity of Winnipeg. Table 3 shows that for the directions of NE, ESE, SSW, SW, WSW, and W, 42 percent of the occurrences of strong wind are associated with a deep low.

TABLE 1

DISTRIBUTION OF OCCURRENCES OF STRONG SURFACE WINDS AT WINNIPEG, PERIOD JANUARY 1961 THROUGH DECEMBER 1963.

(MEAN WINDS GREATER THAN 19 MPH AND/OR GUSTS GREATER THAN 24 MPH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERCENT
N	30	34	96	146	83	17	8	16	16	33	40	66	585	12.3
NNE	17	19	9	63	69	40	9	8	46	25	13	6	324	6.8
NE	1	-	4	30	23	15	3	8	11	3	7	7	112	2.3
ENE	-	-	-	1	2	1	1	4	1	-	-	-	10	0.2
E	-	-	4	2	5	1	1	8	-	2	-	-	23	0.5
ESE	-	4	7	33	9	3	-	4	5	11	8	-	84	1.8
SE	8	8	28	57	21	16	12	23	-	19	8	4	204	4.3
SSE	39	33	93	67	23	59	10	30	61	51	58	34	558	11.7
S	107	70	99	96	65	76	20	27	82	112	145	77	976	20.5
SSW	10	4	15	9	8	18	1	12	33	19	10	4	143	3.0
SW	1	-	2	2	13	11	1	6	4	15	3	1	59	1.2
WSW	4	-	-	-	12	4	12	4	4	14	23	-	77	1.6
W	13	8	4	15	10	10	16	6	17	27	16	11	153	3.2
WNW	16	9	33	13	11	4	15	22	22	23	19	4	191	4.0
NW	120	85	52	46	51	27	35	37	43	49	112	76	733	15.4
NNW	56	31	56	62	68	25	17	27	14	39	55	79	529	11.1
TOTAL	422	305	502	642	473	327	161	242	359	442	517	369	4761	99.9

TABLE 2

SUMMARY OF THE WINDS AT WINNIPEG 1961 - 1963

DIRECTION	ALL SPEEDS NO. OF HOURS (1)	ALL SPEEDS PERCENT OF TOTAL	MEAN SPEED IN EXCESS OF 19 MPH AND/OR GUSTS IN EXCESS OF 24 MPH NO. OF HOURS	MEAN SPEED IN EXCESS OF 19 MPH AND/OR GUSTS IN EXCESS OF 24 MPH PERCENT OF TOTAL
N	2192	8%	585	12%
NNE	1770	7	324	7
NE	1469	6	112	2
ENE	468	2	10	0
E	598	2	23	1
ESE	703	3	84	2
SE	1584	6	204	4
SSE	2175	8	558	12
S	3635	14	976	21
SSW	1358	5	143	3
SW	1121	4	59	1
WSW	819	3	77	2
W	1578	6	153	3
WNW	1408	5	191	4
NW	3016	11	733	15
NNW	2074	8	529	11
CALM	285	1		
TOTAL	26280		4761	

TABLE 3

THE OCCURRENCE OF STRONG WINDS FROM NON-PREFERRED DIRECTIONS FOR WINNIPEG - 1961-1963

WIND DIRECTION	TOTAL OCCURRENCE	OCCURRENCES ASSOCIATED WITH A DEEP LOW IN VICINITY
NE	112	61
ENE	10	0
E	23	0
ESE	84	62
SSW	143	21
SW	59	28
WSW	77	40
W	153	69
TOTAL	661	281

$$\left(\frac{281}{661} \times 100\%\right) = 42\%$$

4. Conclusions

The stronger surface winds at Winnipeg blow from the directions of SSE, S, NW, NNW, W, and NNE. Strong winds from the other direction are possible, and occur primarily with a deep low in the vicinity of Winnipeg.

5. Reference

(1) Summary of Hourly Winds, Tab A. Canada, Department of Transport, Meteorological Branch, Climatology Division.

APPENDIX B

A Check List for Forecasting the Surface Wind at Winnipeg from a Prognostic Surface Chart

A. Geostrophic Wind Direction (from surface prognostic) _____

B. Assumed Backing Angle θ_a (enter A. into Table 1) _____

C. Forecast DIRECTION OF SURFACE WIND (A-B) _____

NOTE: If the direction of the surface wind is 030-130 and 210-280, then strong gusty winds for more than one hour should be anticipated only with a deep low in the vicinity of Winnipeg.

D. Geostrophic Wind Speed (from surface prognostic) _____

E. Simple Peak Gust Factor (enter A. into Table 1) _____

F. Forecast Peak Gust (D. x E.) _____ mph

G. FORECAST MEAN WIND SPEED (enter F. into Table 3) _____ mph

TABLE 1
(simplified)

Geostrophic Direction	Assumed Backing Angle, θ_a	Peak Gust Factor
350-020	40	.8
030-120	50	.6
130-140	40	.8
150-210	30	.9
220	40	.8
230-270	50	.6
280	40	.8
290-340	50	.9

TABLE 2
(simplified)

Calculated PEAK GUST will be correct within

± 3 mph	26%
± 5 mph	44%
± 7 mph	57%
± 9 mph	70%

TABLE 3
(simplified)

Forecast PEAK GUST	Forecast MEAN SPEED
greater than 44	33
35 - 44	25
25 - 34	19
less than 25	13

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