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DEPARTMENT OF TRANSPORT

METEOROLOGICAL BRANCH

A STUDY OF WINNIPEG THUNDERSTORMS

BY

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315 Bloor Street, West,
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ABSTRACT

Thunderstorm occurrences at Winnipeg for an eleven year period have been studied along with various parameters and characteristics in an effort to find correlations which would be of help in forecasting future thunderstorms.

Seasonal and diurnal variations as well as relationships involving precipitation and peak wind speeds are discussed.

ÉTUDE DES ORAGES QUI SE SONT PRODUITS À WINNIPEG

par

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RÉSUMÉ

L'auteur étudie les orages qui se sont produits à Winnipeg au cours d'une période de onze ans en tenant compte de divers paramètres et caractéristiques en vue d'établir des corrélations qui pourraient aider à prévoir les orages futurs.

Il traite aussi des variations saisonnières et diurnes ainsi que des relations où interviennent les précipitations et les vitesses maximales des vents.

A STUDY OF WINNIPEG THUNDERSTORMS

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1. INTRODUCTION

A study has been made of all thunderstorms reported at the Winnipeg Airport for the months of April through October during the 11-year period 1953-1963. Thunderstorms have occurred both earlier and later in the year than this but such occurrences are not normal and have been excluded from this study.

Two hundred and sixty two storms were studied along with their various characteristics such as rainfall amount, peak wind gust, and occurrence of hail. Also considered were the atmospheric conditions prior to the storm outbreak such as temperature, dew-point, surface wind, and upper winds. These various parameters were examined to see if any correlations exist which might be of help in forecasting thunderstorms.

Data concerning these storms were obtained from the following sources:

1. Winnipeg Aviation Weather Reports
2. Winnipeg 850-mb charts
3. Central Analysis Office 300-mb charts

2. SEASONAL AND DIURNAL VARIATIONS

Figure I shows the frequency distribution of the thunderstorms with respect to time of year. It is noted that the storms average 1 or more per week from mid-June to the end of August with a peak of 1.8 per week during the third week of July. In a study of tornadoes on the Canadian prairies, McKay and Lowe (2) showed that the maximum tornado frequency was at the beginning of July. It would seem then that the maximum tornado frequency precedes the thunderstorm maximum by some 2 weeks. Brooks (3) claims that there is a similar displacement of these maxima over the United States, in some states the difference being as much as 2 months.

Connor (4) in "The Climate of Manitoba" lists the average number of thunderstorms per month at Winnipeg during the 37 year period from 1900 to 1936. It is interesting to compare his results with those of the present study. This is done in Table I and it is noted that the frequency of thunderstorms appears greater now than in earlier years. It may

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* This study was undertaken, while Mr. Lipson, a second year honours mathematics and physics undergraduate of the University of Manitoba, was employed as a student assistant with the Meteorological Service of Canada, during the summer of 1964.

actually be that the past 11 years have been stormier than usual; however, it must be pointed out that in recent years observers have been on duty on a 24-hour basis. During the period which Connor studied there was no such continuous observing program and it is likely that many thunderstorms occurring at night, passed by unnoticed. The monthly percentage frequencies for the two periods considered agree quite closely except for August for which the frequency is 6% greater in the more recent period.

Figure 2 shows the frequency distribution of the thunderstorms with respect to the time of day. It is of interest to note that the frequency is not greatest during the time of greatest surface heating but rather in the late evening. Also, as many thunderstorms occur from midnight to 6 AM as from noon to 6 PM. Considering the day as divided into four 6-hour periods the percentage of thunderstorms in each of these periods is: Night (00-05) 24%, morning (06-11) 12%, afternoon (12-17) 24%, evening (18-23) 40%.

3. RELATIONSHIPS INVOLVING THE OCCURRENCE OF THUNDERSTORMS

Figure 3 illustrates the average peak thunderstorm winds associated with various temperature spreads (difference between dry-bulb and dew-point readings). The temperature spreads are those prevailing immediately prior to the commencement of the storm. For temperature spreads of 20 degrees and less there appears to be some correlation, the peak winds generally increasing with the drier air. Above this point, however, any correlation breaks down completely. There are, perhaps, insufficient data at the greater spreads; 80% of the data are for spreads of 20 degrees or less. However, even if a close correlation did exist between peak wind and temperature spread it should not be expected to show up too well in this study since many of the recorded thunderstorms were not close enough to the observing site for their downdraft gusts to reach it.

Figure 4 relates peak wind speed and direction. It is seen that the strongest peak winds come from the two westerly quadrants. This is due, at least in part, to the prevailing west to east motion of weather disturbances. The measured peak wind velocity relative to the thunderstorm and the velocity of the thunderstorm itself. Hence, gust winds from the west are usually strengthened and those from the east weakened.

Figure 4 also shows that peak winds from the northwest are stronger than those from the southwest. This is probably due to the fact that the observing site is partially sheltered by the city to the southwest but is open to the prairies to the northwest.

Figure 5 which gives the percentage frequency of peak wind direction indicates clearly that the peak winds in thunderstorms come most often from the south. The high frequency of south winds is likely associated with the channelling effect of the broad Red River Valley.

Figure 6 illustrates the percentage frequency of the wind direction prior to the storm. In 46% of the cases the wind is between south and southeast. All other directions have relatively low frequencies. Comparing Figure 6 with Figure 5 it is seen that the winds are more from the NW and less from the SE during the storm than prior to the storm.

4. RELATIONSHIPS INVOLVING THUNDERSTORM PRECIPITATION

Figure 7 tends to associate stronger winds with wetter storms. The correlation, however, is certainly not high and some glaring examples of poor fit show up. Thus, the heaviest rainfall amount recorded - 3¼ inches - occurred with a peak wind of only 13 m.p.h. It seems highly probable that this particular thunderstorm developed in over-running air so that ground level was largely shielded from down-draft effects.

In Figure 8 there is the expected tendency for heavier rainfall with higher dew points. The graph should be most reliable in the range of 51 to 65 degrees since over 70% of the data falls in this range. For a dew point between 51 and 65 degrees one should expect between 1/5 and 1/3 in. of rain with the thunderstorm.

5. RELATIONSHIPS INVOLVING PEAK WIND SPEEDS AND DIRECTIONS

Table II shows the peak winds occurring in hail-producing thunderstorms. It is noteworthy that the average peak wind here (41.7 m.p.h.) is considerably higher than the average peak wind of the thunderstorm group as a whole (30.0 m.p.h.).

In Figure 9 the direction of the peak surface wind is plotted against the direction of the 850-mb wind. In 58% of the cases the peak winds are within 22½ degrees of the 850-mb winds. However, there are frequent marked deviations, even when the 850-mb winds are strong. For example, in one instance an 850-mb wind of south 40 was associated with a surface peak wind of northwest 43.

6. RELATION BETWEEN JET STREAM AND THUNDERSTORMS

Central Analysis Office 300-mb charts were examined to seek relationships between the characteristics of the jet stream and the occurrence of thunderstorms at Winnipeg. These 300-mb charts were readily available only for the period 1961-1963, hence this jet stream correlation study is for a 3-year period only. In each particular case, the chart chosen was that falling within the time of 9 hours before to 3 hours after the time of thunderstorm occurrence.

Figure 10 shows the location of the jet stream with reference to Winnipeg at the time of thunderstorm occurrence. By location is meant the point of nearest approach of the stream. It is seen that 36% of the storms occur when the jet stream is within 100 miles of Winnipeg and 77% when it is within 300 miles.

7. FORECAST PEAK WIND SPEEDS COMPARED TO ACTUAL VALUES

Fawbush and Miller (1) have shown that for non-frontal thunderstorms there is a relation between peak wind gusts and the temperature difference between the surface air underneath and in advance of the thunderstorm. The temperature under the thunderstorm is forecast by lowering the wet-bulb temperature at the freezing level to the surface along a saturation adiabat on a pseudoadiabatic chart. Using this relationship it is possible to forecast peak wind gusts.

A check on this Fawbush and Miller method which applies to non-frontal thunderstorms has been made for all Winnipeg thunderstorms during the period 1955-1963 which had peak gusts of 30 m.p.h. or more. The Bismarck radiosonde ascent was used in all cases to determine wet bulb zero, that ascent being chosen which fell within the period 9 hours before to 3 hours after thunderstorm occurrence.

Figure 11 shows the results of this check, the forecast winds being plotted against the actual winds. Fawbush and Miller state that, by definition of the standard error of estimate, 68% of gust predictions should be expected within 8 knots of the actual values. Thus, error curves are plotted on Figure 11 at 8 knots (9.2 mph) above and below the 45 degree line. The majority of points fall below the lower error curve and it therefore appears that peak gusts are over-forecast. However, it must be pointed out that the peak gust from a thunderstorm will not always reach the observing site. It is interesting to note that the highest gust recorded at Winnipeg (79 mph) would have been predicted quite closely (76 mph).

8. CONCLUSIONS

The results of this study may be summarized as follows:

(1) The main thunderstorm period at Winnipeg runs from mid June to the end of August reaching a peak in the third week of July.

(2) Winnipeg thunderstorms occur most frequently during the evening; thunderstorms are as likely to occur at night as in the afternoon.

(3) Thunderstorm gusts are likely to be strongest if they come from the northwesterly quadrant.

(4) A storm which produces hail is likely to have stronger gusts associated.

(5) The jet stream is within 300 miles of Winnipeg on three quarters of the occasions of thunderstorm occurrence.

9. ACKNOWLEDGEMENTS

The author is indebted to Mr. A. B. Lowe of the Winnipeg Forecast Office for his helpful suggestions and guidance.

APPROVED,

J. R. H. Noble,
Director.

10. REFERENCES

(1) Fawbush, E. J., and R. C. Miller: A Basis for Forecasting Peak Wind Gusts in Non-frontal Thunderstorms. Bull. Amer. Met. Soc., January 1954, pp 14-19.

(2) McKay, G. A., and A. B. Lowe, 1960: The Tornado in Western Canada. Bull. Amer. Met. Soc., Vol. 41, No. 1, pp 1-8.

(3) Brooks, E. M., 1951: Tornadoes and Related Phenomena. Compendium Meteor. Boston, Amer. Met. Soc., 673-678.

(4) Connor, A. J., 1939: The Climate of Manitoba, Manitoba Economic Survey Board, Winnipeg, Canada, 145 pp.

TABLE I

COMPARISON OF MONTHLY FREQUENCY OF THUNDERSTORMS FROM 1953 TO 1963 WITH CORRESPONDING DATA FROM 1900-1936 (4).

Month	Number of Storms per Month		Monthly Percentage Frequency	
	1900-1936	1953-1963	1900-1936	1953-1963
April	0.6	0.7	3	3
May	1.9	2.4	10	10
June	4.4	5.0	24	21
July	5.3	6.6	29	28
August	3.7	6.2	20	26
September	2.3	2.6	12	11
October	0.3	0.3	2	1

TABLE II

OCCURRENCE OF HAIL

Year	Date	Hail Intensity	Peak Wind (mph)	A--	A-	A	A+
1963	June 4	A--	25	25			
	July 26	A--	20	20			
1962	July 9-10	A-	39		39		
1960	June 2	A-	68		68		
1959	May 25	A-	62		62		
	June 8	A-	38		38		
	July 4	A+	42				42
	July 8	A+	54				54
	July 14	A-	79		79		
1958	June 28-29	A-	35		35		
	July 24	A-	20		20		
	Sept. 23	A-	28		28		
1957	April 23	A	7			7	
	April 24	A--	30	30			
1956	August 5-6	A	62			62	
	August 10	A	40			40	
1955	June 19-20	A	47			47	
	June 23	A	38			38	
1953	July 4	A-	47		47		
	Sept. 9-10	A-	52		52		
		Total	833/20	75 /3	468 /10	194 /5	96 /2
		Average	41.7	25.0	46.8	38.8	48.0

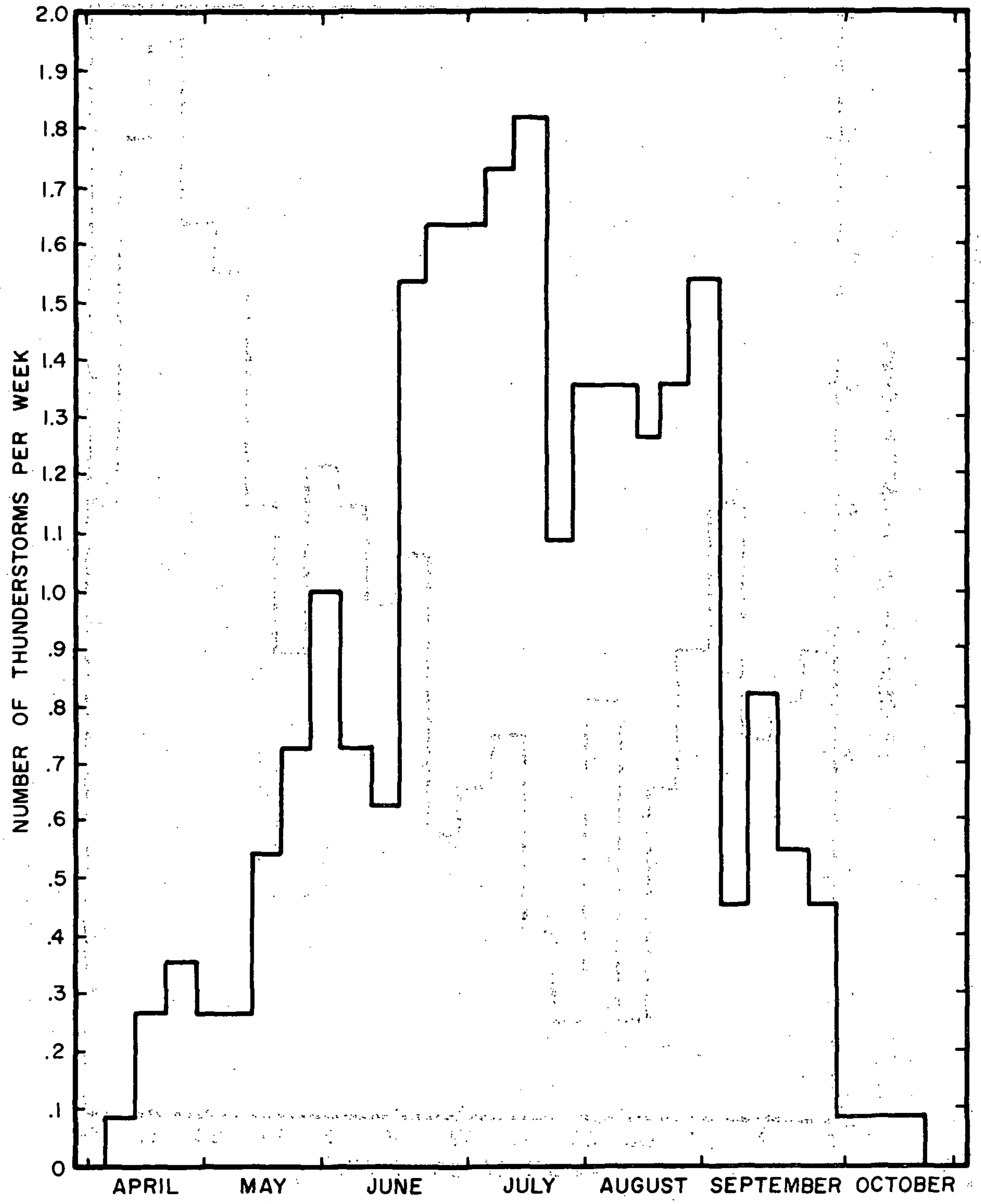


Figure 1
Weekly Frequency Diagram of Thunderstorms at Winnipeg
April 1 to October 27

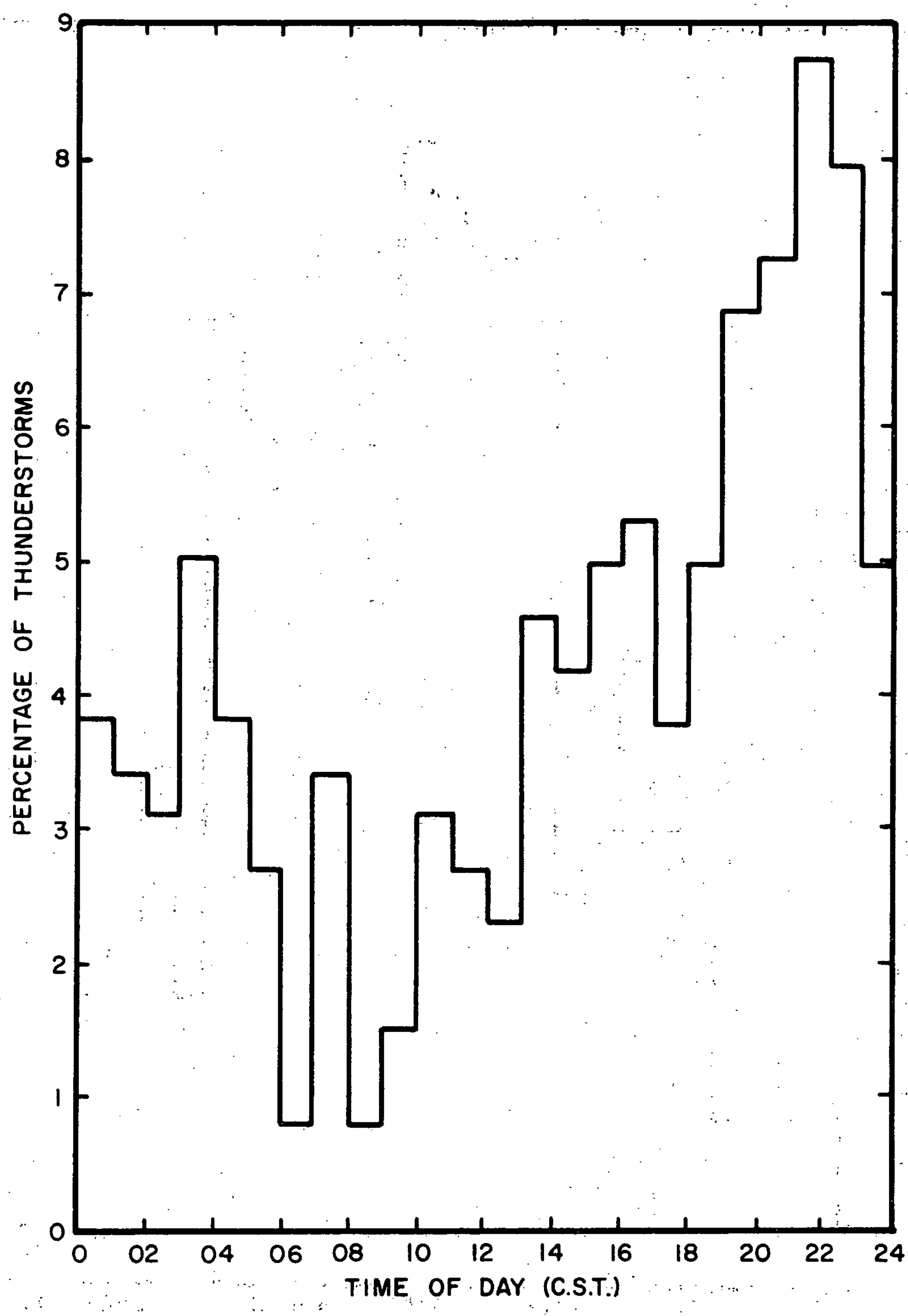


Figure 2
Diurnal Distribution of Thunderstorms at Winnipeg

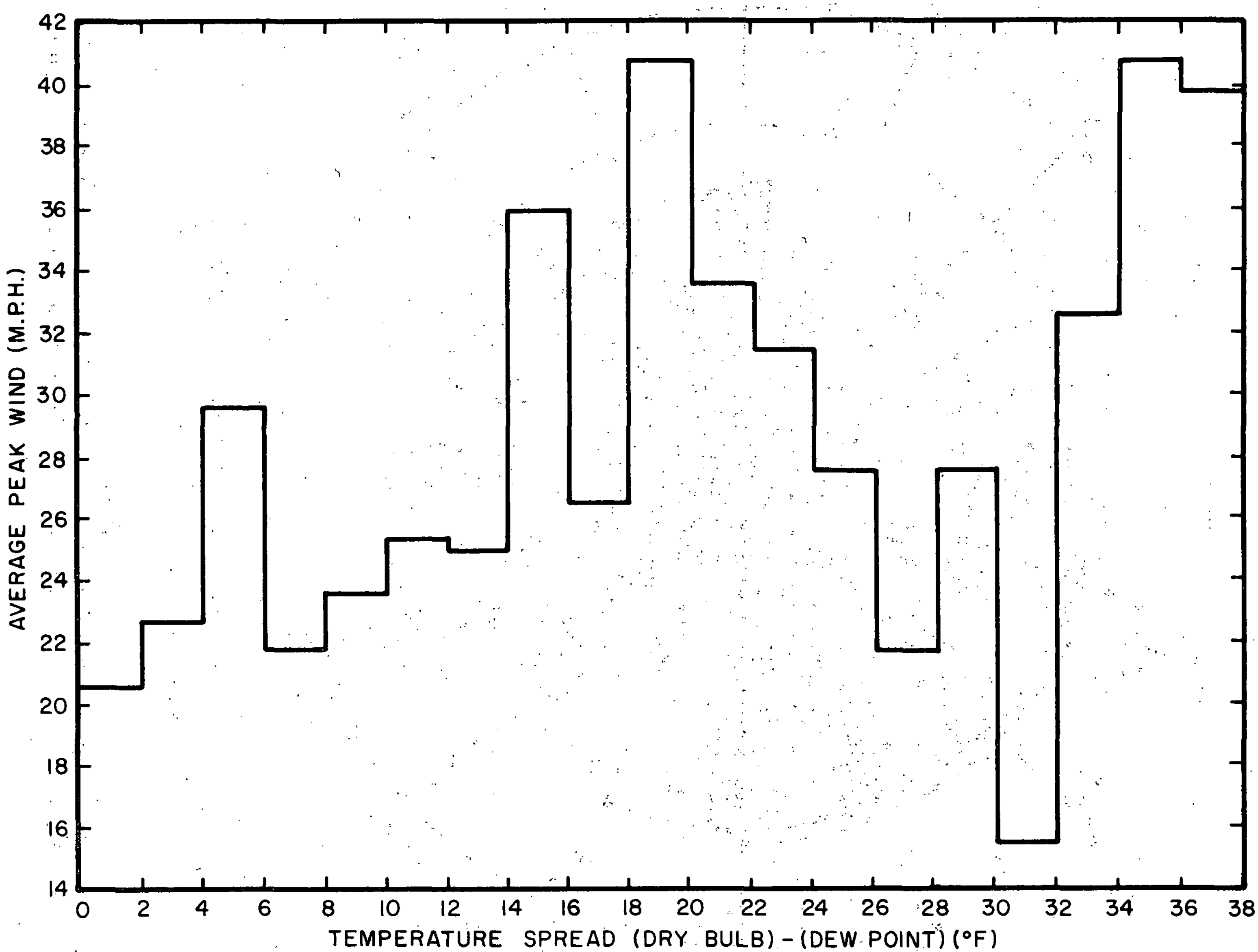
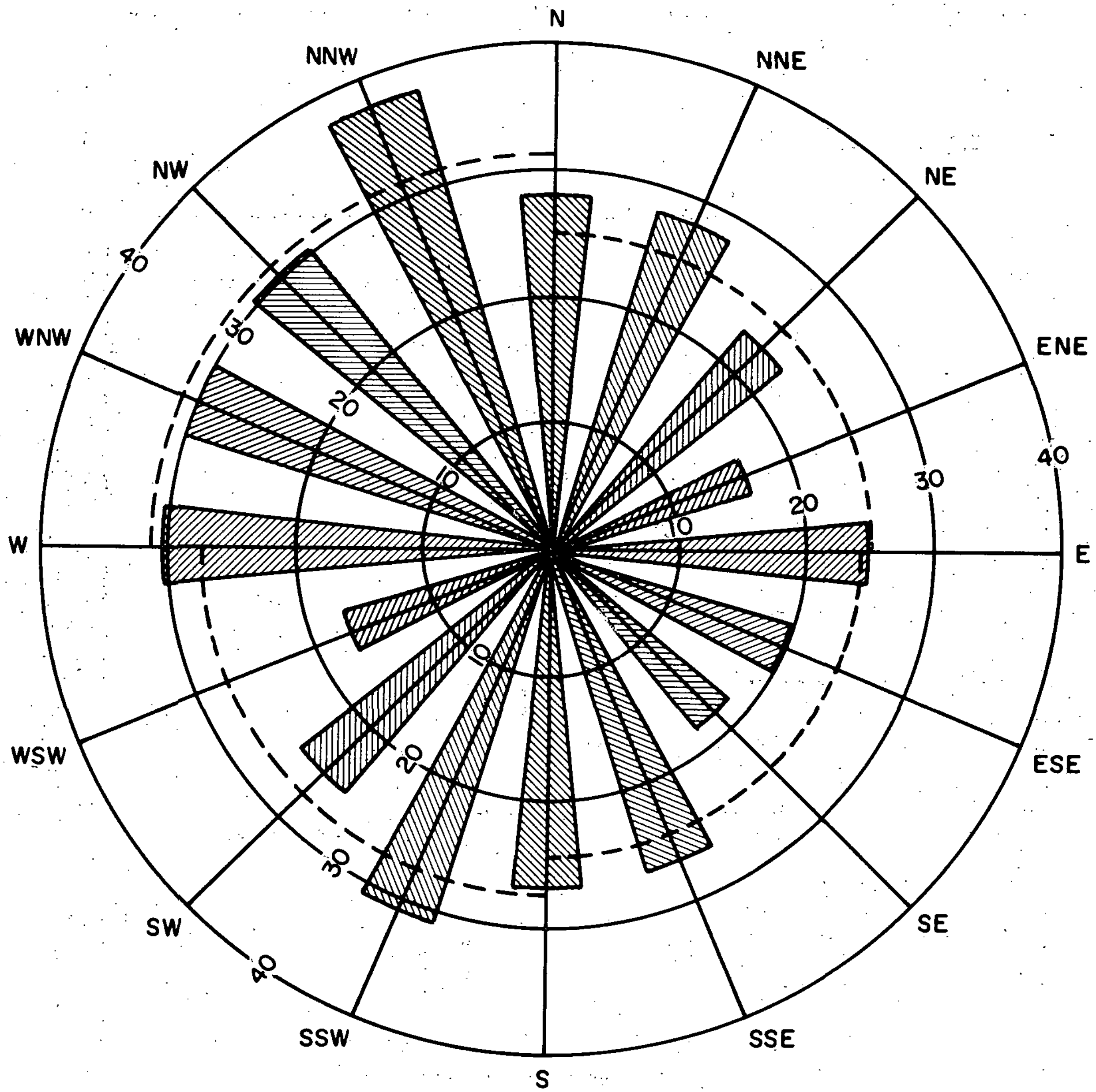


Figure 3
Average Peak Wind Speed vs. Temperature Spread



DOTTED ARCS ARE QUADRANT AVERAGES
WIND SPEEDS ARE IN MILES PER HOUR

Figure 4
Wind rose showing Relationship between Direction and Speed of Peak Winds During Thunderstorms at Winnipeg

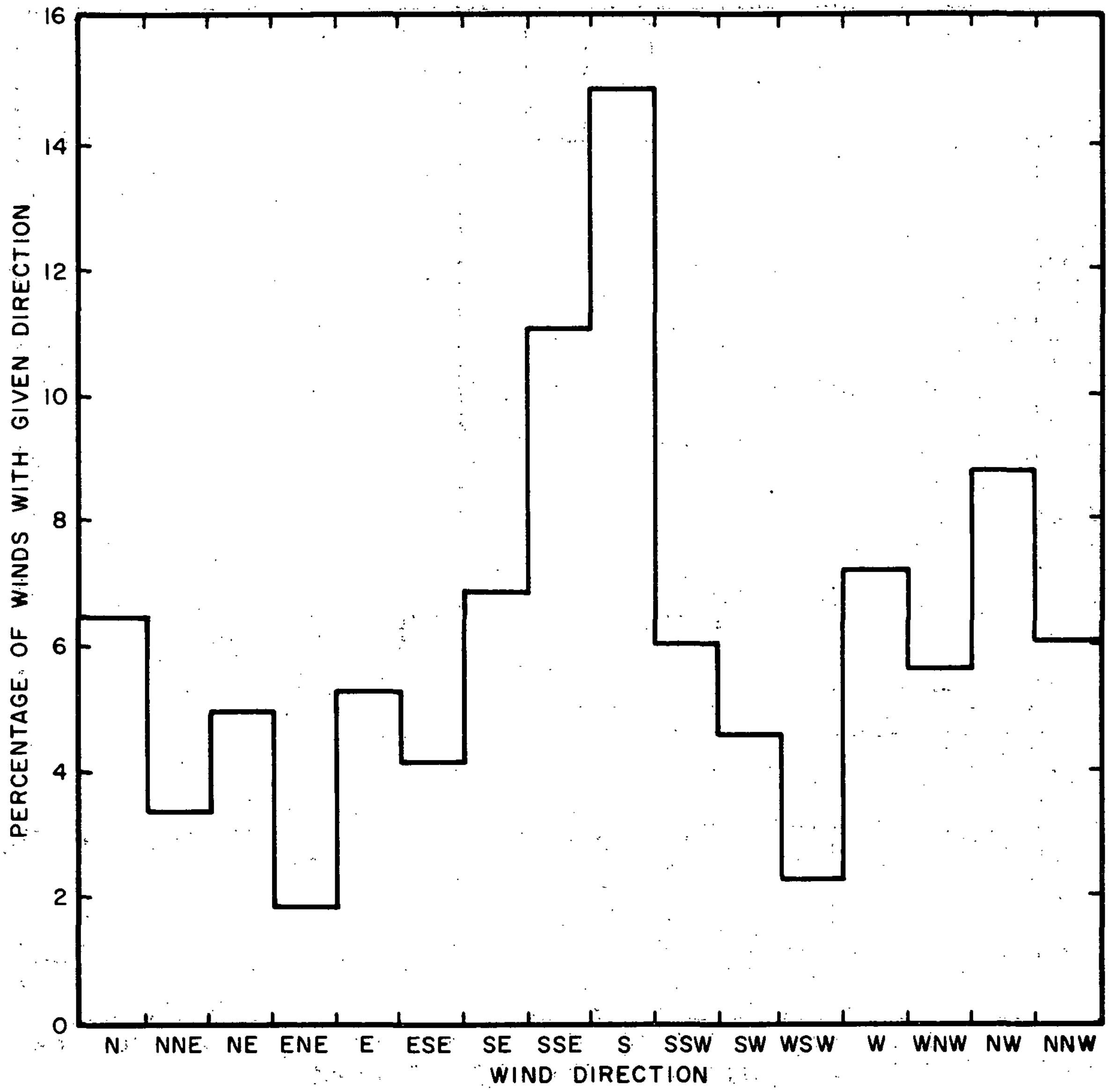


Figure 5
Percentage Frequency of Direction of Peak Wind

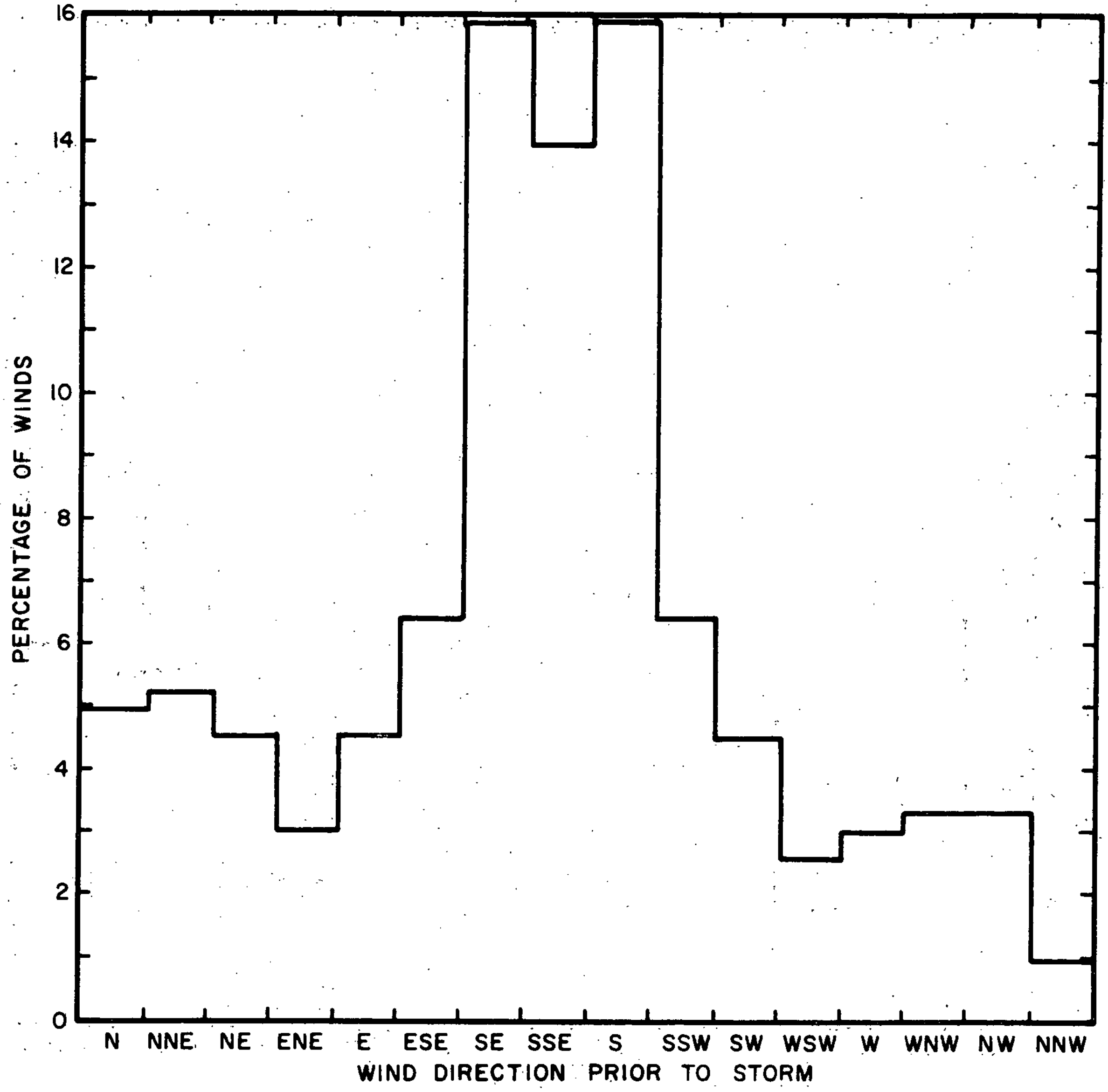


Figure 6
Percentage Frequency of Wind Direction Prior to Storm

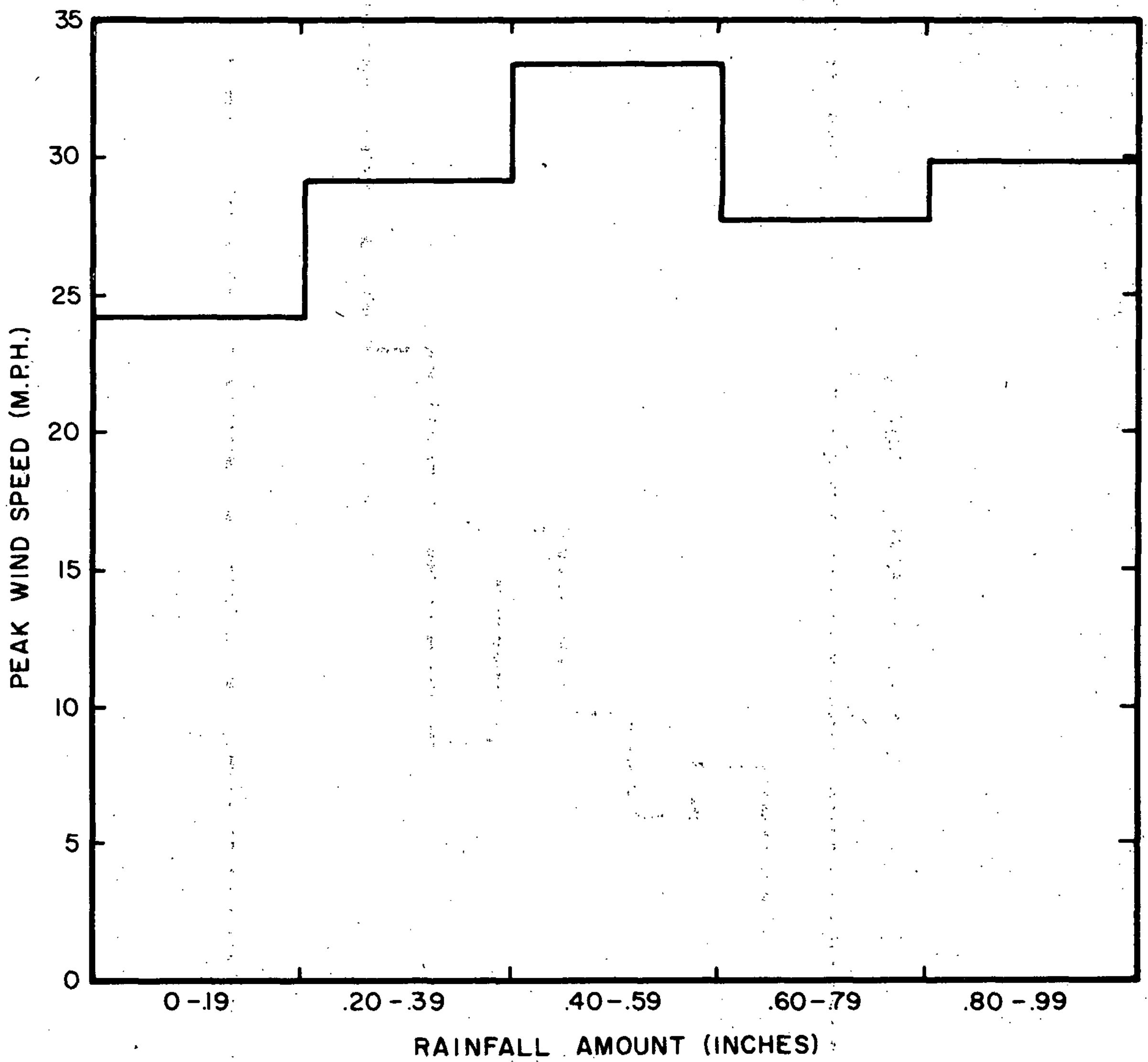


Figure 7
Peak Wind Speed vs. Rainfall Amount

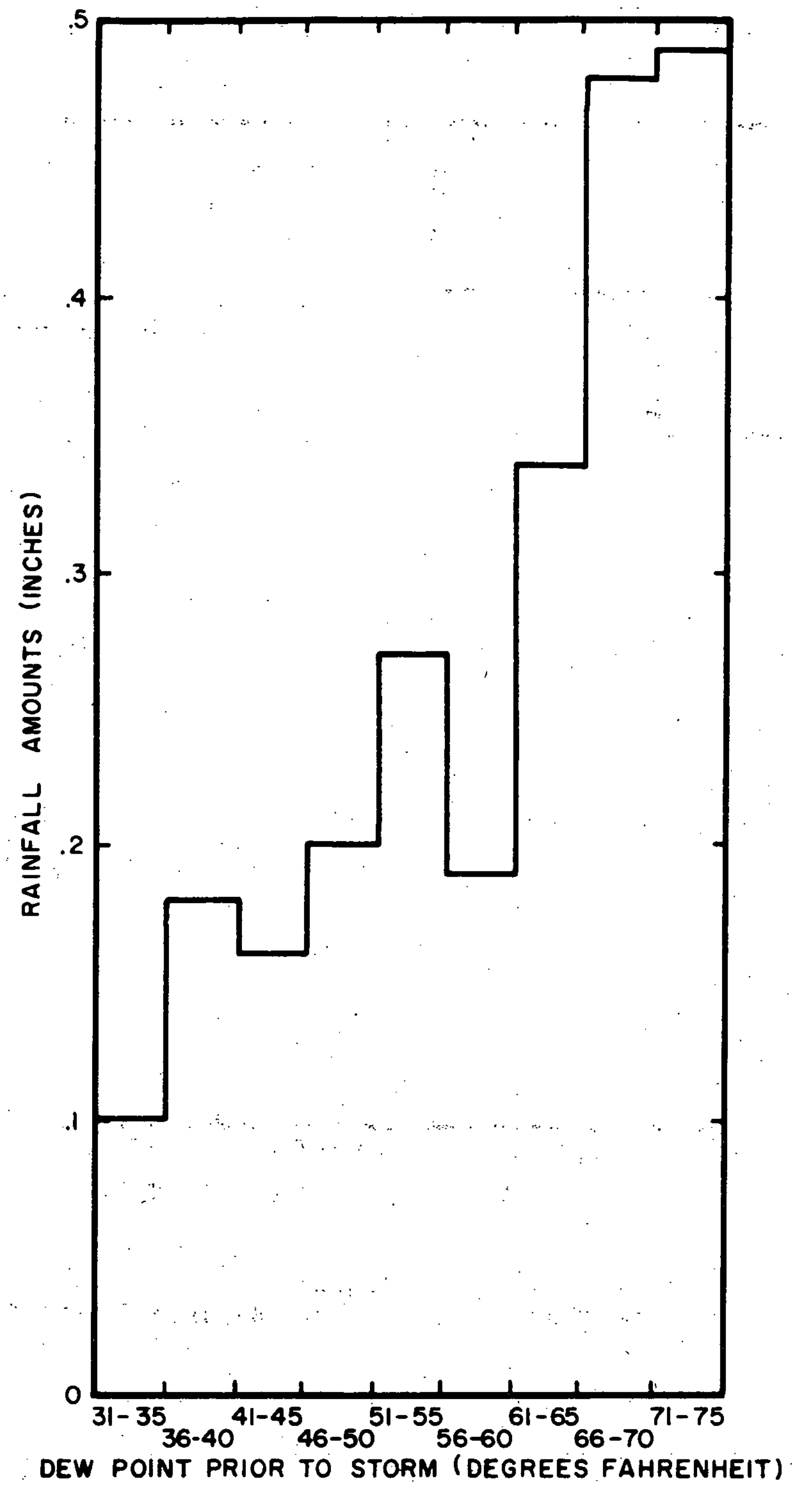


Figure 8
Rainfall Amount vs. Dew Point Prior to Storm

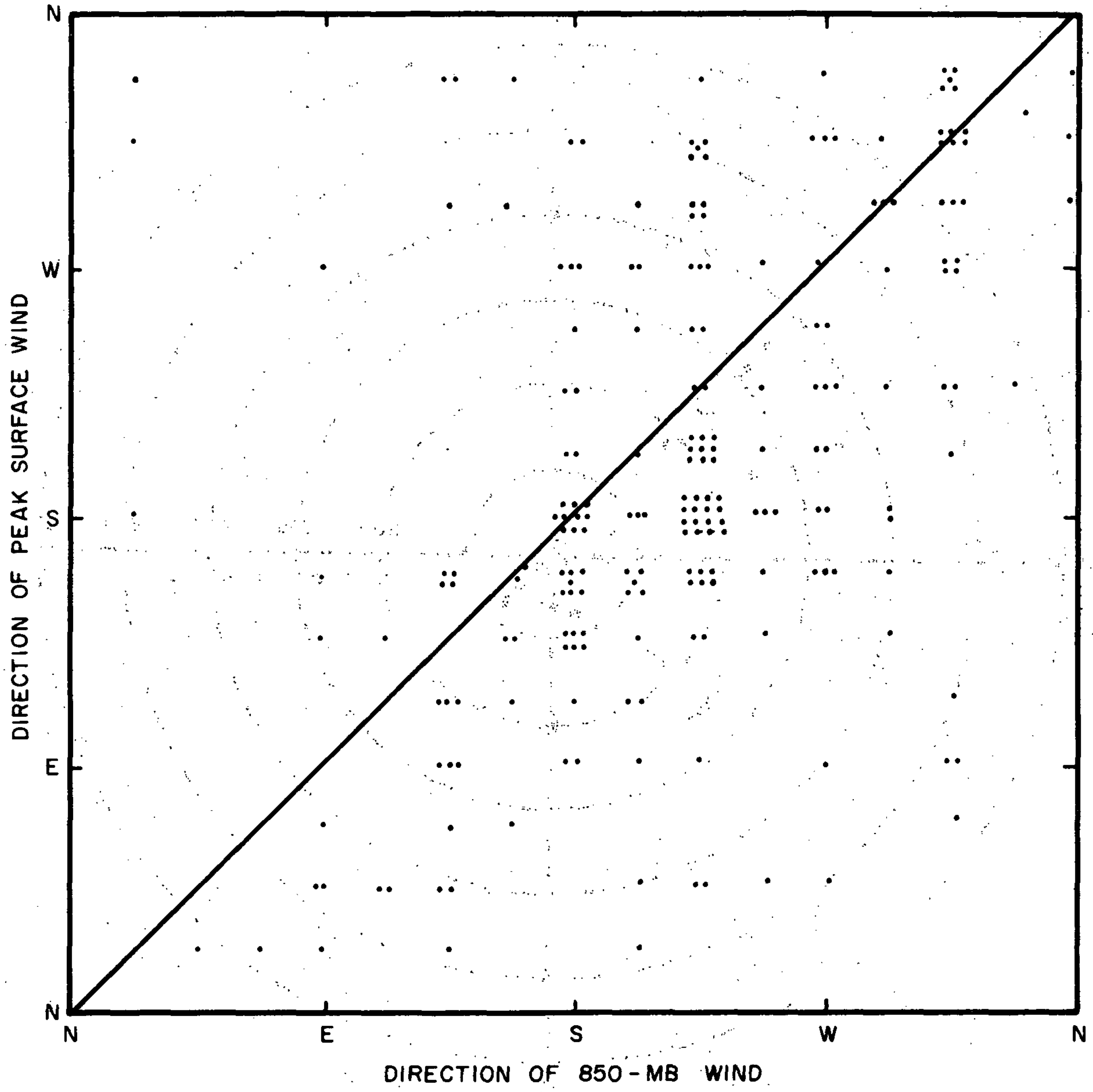


Figure 9
Scatter Diagram of Peak Surface Wind Direction vs. 850 mb. Wind Direction

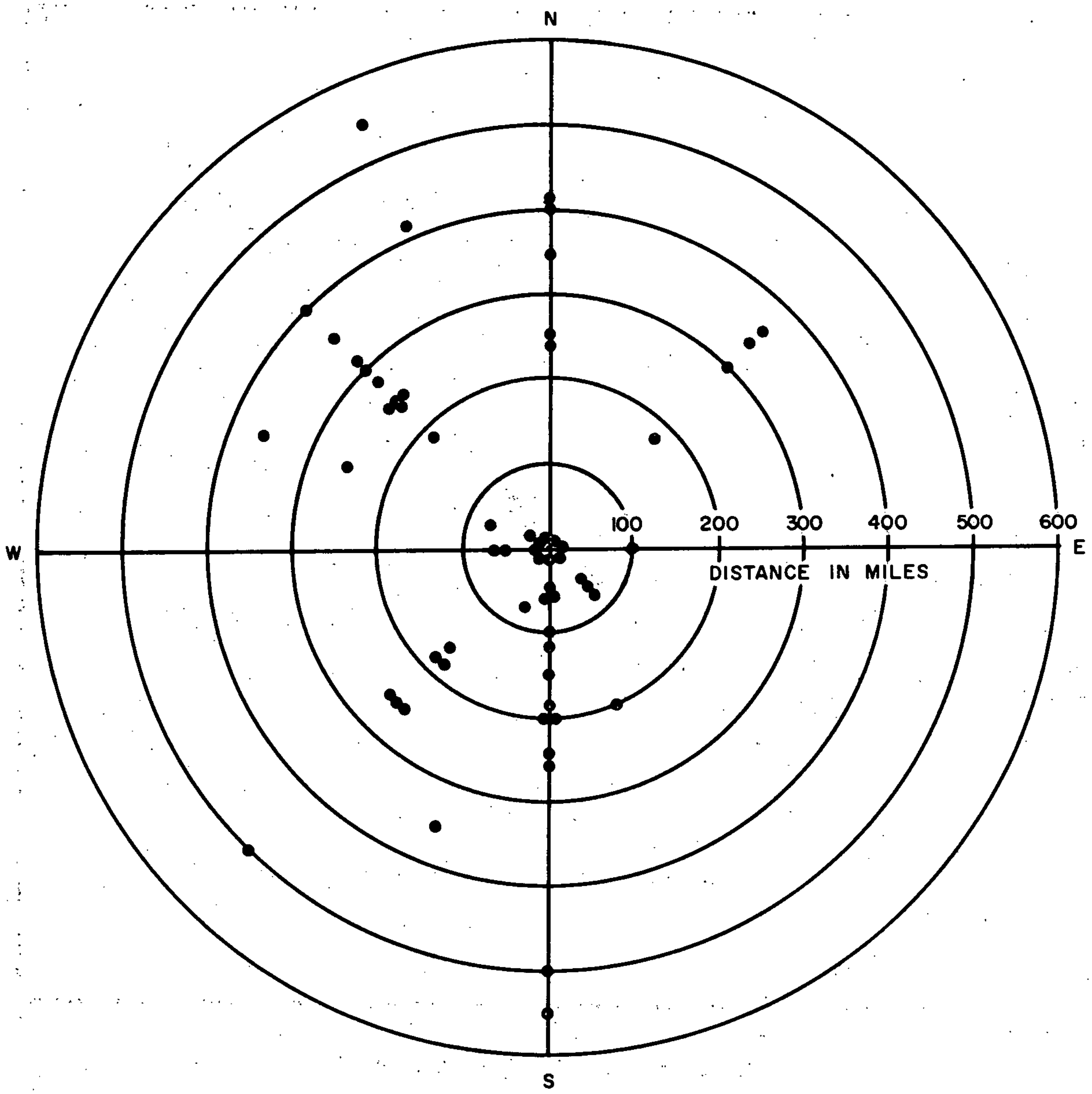


Figure 10
Location of Jet Stream Relative to Winnipeg During Thunderstorms - 1961 - 1963

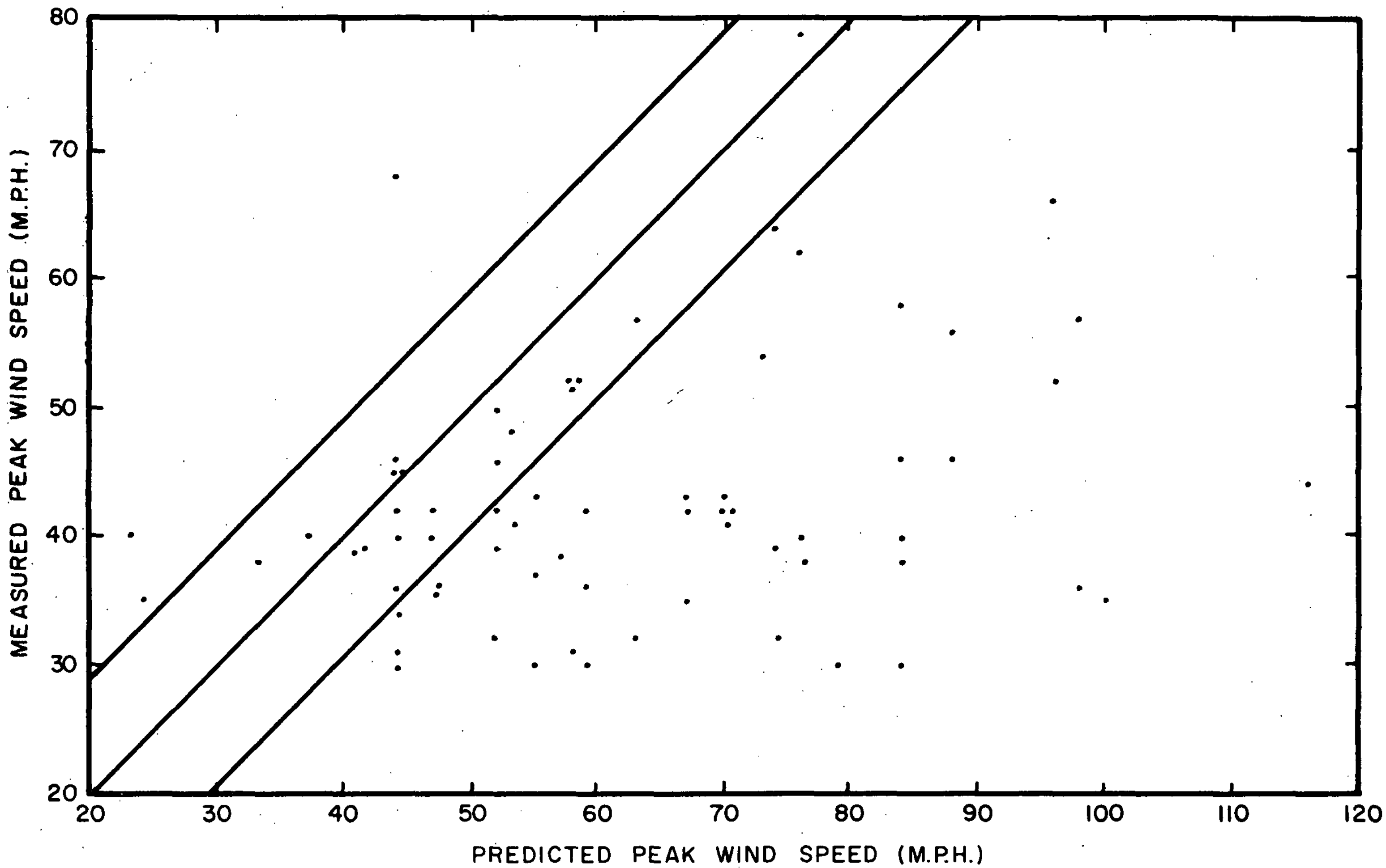


Figure 11
Scatter Diagram of Measured Peak Wind Speed vs. Predicted Peak Wind Speed

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5 pps. 11 figs. 2 tables. 4 refs.

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