Environment Canada Imaging Cover Page

Report N.: *TEC-727*

SKP Box Number: 672672428

CANADA

DEPARTMENT OF TRANSPORT
METEOROLOGICAL BRANCH

Technical Memoranda

CEILING AND VISIBILITY CONDITIONS LOWER THAN VFR AT WINNIPEG AIRPORT

by

A.W. COTT

U.D.C. 551·576·4
551·591·3

TEC 727
October 27, 1969

CANADA - DEPARTMENT OF TRANSPORT - METEOROLOGICAL BRANCH
315 Bloor Street, West,
Toronto 5, Ontario.

CEILING AND VISIBILITY CONDITIONS LOWER THAN VFR AT WINNIPEG AIRPORT

by

A. W. Cott

ABSTRACT

A series of tables and diagrams showing the seasonal, wind directional and diurnal variations of below VFR weather are presented in this paper. A discussion of reasons for these variations of occurrence is included.

PLAFONDS ET VISIBILITÉ INTERDISANT LE VOL À VUE À L'AÉROPORT DE WINNIPEG

par

A. W. Cott

RÉSUMÉ

Cet article renferme une série de tableaux et de diagrammes montrant les variations selon la saison, la direction des vents et le moment de la journée des conditions météorologiques interdisant le vol à vue, ainsi que la discussion des raisons de ces variations de l'occurrence de telles conditions.

CEILING AND VISIBILITY CONDITIONS LOWER THAN VFR AT WINNIPEG AIRPORT

by

A. W. Cott

(Manuscript received May 29, 1969)

INTRODUCTION

This study was carried out with the object of finding the frequency of conditions lower than VFR at Winnipeg Airport and factors which might contribute to these conditions. The relationship of these conditions to wind speed and direction will be considered since some directions are upslope, others downslope, some are from sources of surface moisture, such as large lakes while others are associated with cyclonic activity.

Seasonal frequency will also be considered. Certain seasons are associated with frequent cyclonic activity while others show a low incidence of such disturbances. Some seasons show long nights and short days with small diurnal effects while others show strong daily variations.

ORIGIN OF DATA

The data used are largely statistical, the material having been abstracted from the publication "Meteorological Conditions at Canadian Airports". This material covers the ten year period 1954-1963 inclusive. In addition, weather conditions below VFR were extracted from the hourly reports for 1957 and 1961. The purpose was to determine the main causes of low weather.

DIAGRAMS

The contour type diagram was used throughout this study. The following diagrams were developed and are included at the end of this report, and the manner in which the frequencies were computed for the various diagrams is as follows:

(a) Figure 1.

Ratio of the number of cases in a given month less than 1,000 and/or 3 for a given wind direction (multiplied by 100) to the total number of hours in that month.

(b) Figure 2.

Ratio of the number of cases in any month less than 500 and/or 1 for a given wind direction (multiplied by 100) to the total number of hours in that month.

(c) Figure 3.

Ratio of the number of cases in any month less than 200 and/or $\frac{1}{2}$ for a given wind direction (multiplied by 100) to the total number of hours in that month.

(d) Figure 4.

Ratio of the number of cases in any month less than 1,000 and/or 3 for a given wind direction (multiplied by 100) to the total number of cases of that wind direction for that month.

(e) Figure 5.

Ratio of the number of cases in any month less than 500 and/or 1 for a given wind direction (multiplied by 100) to the total number of cases of that wind direction for that month.

(f) Figure 6.

Ratio of the number of cases in any month less than 200 and/or $\frac{1}{2}$ for a given wind direction (multiplied by 100) to the total number of cases of that wind direction for that month.

(g) Figure 7.

Diurnal variation of ceilings less than 1000 feet and/or visibilities less than three miles.

(h) Figure 8.

Diurnal variation of ceilings less than 500 feet and/or visibilities less than one mile.

(i) Figure 9.

Diurnal variation of ceilings less than or equal to 200 feet and/or visibilities less than or equal to one-half mile.

Lines indicating sunrise and sunset time are included in Figures 7, 8 and 9.

The data for Figures (7), (8) and (9) are the percent ratio of all occurrences of a given range at a specific time of day in each month to the total number of hours in the month for the ten year period. The purpose of these diagrams is to show diurnal variation. Seasonal variations show up as well.

The maximums of the data in most cases occurred in the fall, winter and spring and generally for the wind directions north and south. Thus the diagram axes of Figures (1) to (6) were begun with July and the wind direction west so that the maximums occur more in the centre of the diagram and are not split by the edges.

TOPOGRAPHY AND TERRAIN OF WINNIPEG

Winnipeg is situated in the shallow Red River Valley at an elevation of 786 feet, about 30 miles south of the point where the river terminates in Lake Winnipeg. The valley has a general north to south direction with the very shallow Assiniboine Valley running west from the city.

To the west of Winnipeg, the terrain has a gentle rise to the escarpment containing the Riding Mountains, Turtle Mountains, Duck Mountains and Porcupine Hills where the rise is abrupt. Heights of 2,400 feet are reached in a distance of less than 100 miles west of the airport and heights of 2,700 feet are reached along the escarpment.

The Red River Valley slopes gently downward from south to north having an elevation of 980 feet at a point 300 miles south of Winnipeg and 720 feet at the mouth of the river in Lake Winnipeg. Northeasterly and northerly winds are gently upslope. Easterly, westerly, southwesterly, southerly and southeasterly are downslope with respect to Winnipeg Airport.

The terrain to the east of Winnipeg is essentially a broad plain reaching an elevation of around 1,000 feet at a distance of 50 miles. It is swampy and heavily forested. To the North and northwest lie the valleys of Lakes Winnipeg, Winnipegosis and Manitoba. This is a flat area narrowing from north to south. The north end of Lake Winnipeg has widths of up to 60 miles, whereas in the south end, its width is about 25 miles at the widest point falling to about 5 to 6 miles at the narrows. The lakes and surrounding swampy areas form a source of moisture when the lakes are ice free. In the fall and early winter, the lakes are warmer than the surrounding land areas. During the spring and early summer the reverse is true. The lakes are cold relative to the land and until well into May are covered with ice. Convergence effects are noted with northerly flows due to the friction free path along the lakes in contrast to the rough terrain surrounding them.

WEATHER CONDITIONS BELOW VFR

Table 1.

Percent of Time Conditions are Less than VFR

Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
9.9	11.5	8.8	5.8	6.4	4.8	2.1	2.7	5.8	8.1	14.1	13.9	7.7

Winnipeg is a relatively good weather area showing conditions below VFR only 7.7% of the time, on the average. Figure 1 shows that the peak period is the late fall and winter when ceilings and visibilities less than VFR occur 10% or more of the time. November and December have the highest frequency. This is the fall period of maximum cyclonic activity when Lakes and swamp are still ice free, acting as sources of moisture and heat.

W.H. Klein in his paper "Prevailing Tracks of Lows and Highs" has established that there are two periods of maximum cyclonic activity at Winnipeg. These occur in the spring and fall. The spring peak occurs as the main track moves northward to its normal position near 60 degrees north and the fall peak as the main track moves southward to its normal winter position from the Colorado Basin eastward. These two peaks show up in Table 1. Winter is a period of considerable cyclonic activity due to inverted surface pressure troughs extending northward from disturbances to the south. The spring peak of 6.4% which occurs in May is much smaller than the fall peak which occurs in November and is indeed smaller than the frequency for any month in the period October through March, (see Table 1). Following are reasons which probably contribute to the difference.

In the fall the lakes and swamps to the north are open and warmer than many of the colder air masses which affect the region. Thus the air mass is warmed as it crosses the water, picks up moisture and then is again cooled as it moves across the land by upslope, by convergence and also by the fact that the land is colder than the water, particularly at night. This was discussed by Reimer in "A Study of the Occurrence of Stratus and Drizzle at Winnipeg on September 6, 1957" and an addendum to this study by R. Lee.

In spring on the other hand, the lakes and swamps are first frozen and even after break-up are very cold compared to the land. Consequently the same process of heating, picking up moisture and then cooling is lacking. Only when warm moist air masses cross the cold lakes and are cooled by contact, upslope and convergence, do low ceiling conditions result.

Further, diurnal effects are more marked in spring when days are lengthening and rays of the sun more direct than in fall, when the shortest day is approaching. Consequently in the fall with the above processes taking place, daytime heating may not be sufficient to raise the air temperature high enough to dissipate the cloud.

The absolute minimum of cyclonic activity is summer, when the primary track is well to the north of Winnipeg. Although most disturbances track well south of the area in winter, the Winnipeg region is still affected by inverted surface pressure troughs extending northward from individual depressions, the precipitation and cloud associated and by southerly and easterly flows of moist stable air accompanying the systems.

Table 2.

The Frequency of Various Weather Phenomena Accompanying Conditions Below VFR by Month Derived from Data for 1957 and 1961

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Total cases	81	157	87	72	50	82	18	22	79	102	152	169
Percentage accompanied by snow and blowing snow	63	61.7	27.8	34.7	-	-	-	-	-	2.9	16.4	34.9
Percentage accompanied by fog and/or smoke	17.3	10.2	24.1	12.8	-	3.7	27.8	54.6	13.9	19.6	27.0	21.8
Percentage accompanied by stratus	19.7	32.5	54.1	86.2	100	96.4	76.8	45.5	86.1	85.3	64.4	56.2

Table 2 was extracted from the hourly reports for 1957 and 1961, two years chosen at random. The table shows the phenommena accompanying conditions below VFR. Some of the columns do not add exactly to 100% since where ceilings and visibilities both contribute to the condition, each are calculated separately as the cause of the low weather. Once again the fall, winter and spring maximums show up by comparison of the monthly "Total cases". Snow and blowing snow is the leading cause of weather lower than VFR in January and February, and in August the main cause is fog and smoke while stratus is the major contributor in all other months.

Figure 1 shows that the main wind directions occurring with below VFR weather are north, south and northwest, the direction from which most winds blow. Most of this weather accompanies cyclonic activity. Southerly winds bring in moist stable air from the south with consequent cooling and stratus formation when the land is colder than the air. Precipitation associated will reduce ceilings and visibilities as depressions move across the area to the south. North winds show weather due to heating and picking up moisture from surface water sources as described above. Upslope, surface contact cooling and convergence will contribute to this weather caused by winds from northerly directions while downslope with southerly winds may inhibit low cloud formation.

Figure 4 shows that the greatest risk of weather in this range is with easterly and northeasterly winds. However these winds are relatively infrequent compared to those from the three prevailing directions. The highest risk is in November when these two directions are accompanied by weather lower than VFR more than 28% of the time. In February there is a risk of 32% with easterly winds only. In addition to reasons for below VFR which have been discussed for south and north winds, east winds blow directly from the city across the airport. The city acts as a heat island and is in addition a possible source of low weather due to smoke and man-made condensation nuclei which may increase the tendency to form low cloud, fog and other obstructions. Calm conditions are accompanied by ceilings and visibilities less than 1,000 feet and/or 3 miles only 9% of the time. Calm weather generally occurs in large flat highs where moisture content is small.

In general there is a stronger risk of low conditions with north winds than south due to the fact that north winds are upslope, have a constant source of moisture, when lakes are ice free, and are associated with frictional convergence since northerly flows are less impeded than are northwesterly and northeasterly flows. South winds are downslope.

Conditions below VFR most frequently are accompanied by winds 10 mph or greater. The highest frequency is with winds in the range 10-19mph (see Table 3). This is normal since southerly winds accompanying depressions are strong due to gradient and channelling effects. Northerly winds not only accompany strong gradients, but are unstable due to heating below and blow along the relatively friction free surface of Lake Winnipeg. In all months except July, August and September, at least 65.6% of weather in this range is accompanied by winds 10 mph or higher.

Table 3.

Percentage of Below VFR Weather which is Accompanied by Various Wind Speed Ranges

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Calm	1.2	1.0	0.9	1.4	0.0	0.3	1.3	1.3	1.7	1.8	0.4	0.8	0.8
1-9mph	31.4	31.3	31.4	18.9	10.8	30.1	41.3	36.9	35.9	30.7	34.0	29.0	29.9
10-19mph	37.3	35.0	41.4	40.2	42.3	49.6	49.6	43.9	47.6	46.8	43.0	37.3	41.4
20+mph	30.1	32.7	26.3	39.5	46.9	20.0	7.8	16.7	14.8	20.7	22.6	32.9	27.9

From Table 3 it is obvious that 80% or more of below VFR weather in July, August and September, occurs with winds in the 1 to 19 mph range. It also shows that there is a higher frequency of these conditions in the range below 10 mph than in any other months. Table 2 indicates that the main contributors to below VFR conditions in these months are fog and stratus. A study of weather records for the years 1957 and 1961 show that 40% of conditions in this range in the above noted months occur with fog. The frequency of very strong winds in these months is small due to the low level of cyclonic activity.

WEATHER LESS THAN 500 FEET AND/OR 1 MILE

Table 4.

Percent of Time Conditions are Less than 500 Feet and/or 1 Mile

Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
2.1	3.8	2.6	1.8	1.5	1.5	0.7	0.8	2.1	3.2	5.8	4.8	2.6

This condition occurs only an average of 2.6% of the time with a maximum frequency of 5.8% in November and 4.8% in December. From October to March this range occurs more than 2% of the time and reaches a minimum of less than 1% in July and August. Figure 2 shows that these ceilings and visibilities have a marked fall and winter maximum with southerly and southeasterly winds. They are accompanied by winds 10 mph or higher 60% of the time and 22% of the time by winds 20 mph or higher. This would appear to indicate that at these times low conditions are generally produced by precipitation accompanying cyclonic disturbances which at this time of year track near or just south of Winnipeg. All wind directions have a relatively high winter frequency.

Table 5.

Frequency of Various Weather Phenomena Accompanying Conditions Below Ceiling 500 Feet and/or Visibilities 1 Mile by Month Derived from Data for 1957 and 1961

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Total cases	19	46	26	20	6	17	4	7	32	39	67	52
Percentage accompanied by snow and blowing snow	42.1	63.1	30.8	35.0	-	-	-	-	-	-	-	13.5
Percentage accompanied by fog and/or smoke	31.6	15.2	53.9	5.0	-	5.9	25.0	85.8	25.0	25.6	44.8	57.7
Percentage accompanied by stratus	31.5	21.7	23.1	65.0	100	94.2	100	42.9	75.0	79.5	52.3	48.1

Table 5 gives the weather phenomena most usually accompanying conditions less than ceilings 500 feet and/or visibilities 1 mile. Winter and early spring show a high frequency of snow and blowing snow. Figure 2 shows that there is a winter maximum associated with northerly winds (.90 in February). A study of data from 1957 and 1961 indicates that northerly winds and southerly winds both are frequently associated with conditions in this range due to snow and blowing snow. J. J. Labelle et al showed in their study of the Climate of Winnipeg, pp42, and 43, that there is a tendency for most very strong winds to be southerly, northerly or northwesterly. This is partly due to channelling along the Red River Valley and the long path of low friction along Lake Winnipeg. Frozen precipitation will accompany southerly winds ahead of depressions and inverted troughs.

Northerly winds will follow immediately behind the system. Loose snow dropped as the depression passes, will contribute to the low conditions when blown by the strong northerly winds.

Figure 5 shows the greatest risk of this condition is with northeast or east winds in the fall and winter, similar to the pattern for below VFR. However the magnitude of the risk is less than half of that for VFR.

In summer, on the other hand, this range or ceilings and visibilities is frequently accompanied by north winds. At this time cyclonic activity is at a minimum with the track far north of Winnipeg. Thus this weather in summer frequently accompanies relatively cold outbreaks from the north. The air is warmed and picks up moisture as it crosses the lakes. At the time of maximum cooling near sunrise the land is colder than the water, thus the air is cooled again as it passes from the water, producing a low level inversion and stratus formation. This effect is accentuated further by upslope and convergence. This process was pointed out by Reimer, and addendum by Lee, 1958. Summer is also a time of weak gradients. Consequently fog frequently produces weather in this range.

CEILINGS AND VISIBILITIES LESS THAN 200 FEET AND/OR ½ MILE

Table 6.
Percent of the Time Conditions Less than 200 Feet and/or ½ Mile Occur

Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
0.6	1.1	0.8	0.4	0.2	0.2	0.1	0.1	0.5	0.9	1.7	1.2	0.6

This range of conditions occurs only 0.6% of the time during the year. November shows a maximum of 1.7% of the time with December and February occurrences averaging more than 1% of the time. May through August occurrences are 2/10 of 1% of the time or less.

Table 7.

Percentage Frequency of Various Weather Phenomena Accompanying Conditions below 200 and/or $\frac{1}{2}$ by Month Derived from Data for 1957 and 1961

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Total cases	5	5	10	6	-	1	1	2	5	8	26	12
Percentage accompanied by snow and blowing snow	-	60.0	20.0	100.0	-	-	-	-	-	-	-	-
Percentage accompanied by fog and smoke	60.0	40.0	80.0	33.3	-	100.0	100.0	100.0	100.0	87.5	92.4	91.7
Percentage accompanied by stratus	40.0	-	-	33.3	-	-	-	-	-	12.5	7.7	8.3

This weather is most frequently associated with north and south winds with a minimum occurrence with southwest and east winds as shown by Figure 3. As pointed out southerly winds frequently bring in moist stable air and are frequently associated with precipitation ahead of depressions. North winds tend to pick up moisture as they cross the warm lakes in the fall and subsequent poor weather is accentuated by upslope, convergence and occasionally overnight cooling. Southwest winds are downslope. Although they show only gentle downslope in the vicinity of Winnipeg over the large scale they are markedly so due to the escarpment to the west. Over 60% of this condition occurs with winds 0-9 mph indicating it is primarily a fog condition. However in winter 50% or more of the occurrences are with winds 10 mph or higher indicating that at this time of year it is frequently a snow or blowing snow condition. Table 7 confirms the above conclusions.

Figure 3 shows the same seasonal and directional maxima of poor weather as for the higher ranges. Figure 6 again indicates the highest probability is with winds from the northeast and east for similar reasons to those discussed for below VFR weather.

DIURNAL VARIATION OF LOW WEATHER CONDITIONS AT WINNIPEG AIRPORT

It is difficult to distinguish between air mass conditions with strong moisture advection and migratory cyclonic systems producing low weather. However a study of Figures 7, 8 and 9 showing diurnal variation of conditions (7) less than 1000 feet and/or 3 miles, (8) less than 500 feet and/or 1 mile and (9) less than 200 feet and/or $\frac{1}{2}$ mile brings out certain salient facts.

First, the highest frequency of weather in each of these categories occurs just after sunrise. This is the time of maximum radiational cooling and the beginning of mixing due to the start of daytime heating. Also at this time there is likely to be a surface inversion due to night time cooling. Consequently the necessary mechanisms for producing low cloud are present, if sufficient moisture is present.

Secondly it is noted that diurnal effects are pronounced in November and December in Figures 7 and 8 and in November alone in Figure 9. Low stratus and stratocumulus are more likely to persist all day at this time. This indicates, for one thing, that the effects of daytime heating are small as the days shorten and we get less direct rays from the sun. This is also the time when migratory storm tracks are nearest. Thus, we get frequent injections of moisture ahead of the disturbances and behind them. The lakes and swamp areas to the north are potential sources of heat and moisture. The prevailing wind direction is north. This, along with the longer periods of radiational cooling as the nights increase in length, leads to an increase in low cloud. A second peak shows in February in all the Figures and March as well in Figure 9. Following this, there is a gradual decrease until the summer minimum is reached.

Conditions less than VFR most frequently occur in November through February. The actual maximum period lies between 9 and 11 a.m., in these months, with high frequencies developing just before sunrise and reaching a peak one to three hours later. In January and February it appears that this early morning low condition will have increased to above VFR in about 50% of the cases by noon. In October, November and December, March and April, the 50% improvement does not occur until mid-afternoon. May and June show their highest frequency from 5 to 11 a.m. and July and August and September 5 to 9 a.m.. The frequency of conditions below VFR after noon is very low in summer and is likely entirely associated with migratory systems and rain or thunderstorm activity.

In the range of weather less than 500 and/or 1 again the low diurnal variation in November and December is prominent. In fact in most respects diagram 8 is similar to that for lower than VFR. The peak frequency is just after sunrise. The winter months show a 50% improvement by 11.00 a.m.. In November and December, this improvement occurs in the early afternoon with November showing an increase in low weather from 10 p.m. on. The only significant amounts of this condition in summer are about 6 a.m. with virtually none from 8.00 until midnight from April through September.

Figure 9 displays a similar peak for conditions lower than 200 and/or $\frac{1}{2}$. Even in the peak weather months, weather in this range is largely ended by 11 a.m. and virtually never occurs after 8 a.m. in June, July, August and September. It is extremely rare at any time from April through September.

SUMMARY AND CONCLUSIONS

1. Winnipeg, having a continental climate, has relatively small amounts of weather lower than VFR.

2. Most weather in these ranges is associated with the prevailing wind directions (N. NW and S).

3. October through February is the main period of low weather with the highest frequency actually occurring in November and December. This is a period of maximum cyclonic activity with frequent cold outbreaks. Nights are long, days short and solar insolation amounts small. Northern regions are sources of considerable heat and moisture until freeze up takes place.

4. Although spring is a period of maximum cyclonic activity, there is much less low weather than in the fall. Northern lakes and swamps are frozen into early May. Nights are getting shorter, days long, and solar insolation is increasingly effective.

5. There is a relative minimum of poor weather in January since this period is dominated by Arctic highs. However the main storm track is south and with the passage of depressions there is considerable precipitation in the form of snow. Further, these depressions are often accompanied by northeasterly upslope winds of stable moist southerly and easterly flows.

6. Summer is a period of small frequency of low weather. Since the main storm track is far north only infrequently is the area affected by cyclonic disturbances. Occasional well modified cool outbreaks occur giving brief periods of low weather. Air masses are relatively dry with only scattered convective activity.

7. North and northeast winds show a high probability of low weather since this is an upslope direction with effects compounded by frictional convergence between Lake Winnipeg and the city. These winds also accompany cold outbreaks with consequent turbulence, inversions and large amounts of moisture.

ACKNOWLEDGEMENTS

The author is considerably indebted to Miss Lynne Little, Miss Carol Kaplonski and Mr. G. E. Bachers who aided in the preparation of this paper through extraction of data, calculation of percentages and drawing of charts. He is further indebted to Mr. A.H. Lamont for his help in interpretation of data and suggestions for improving presentation.

APPROVED,

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

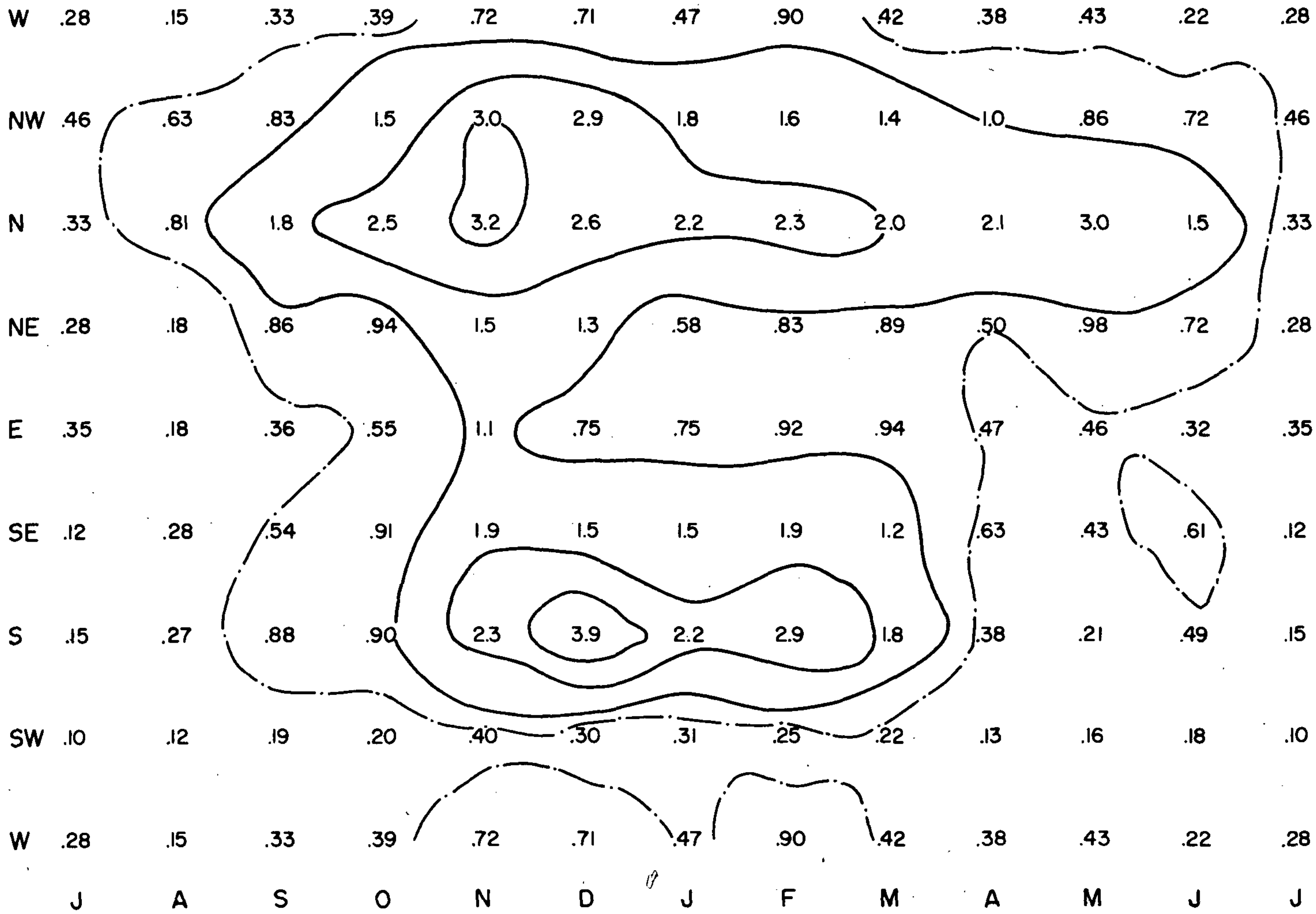

Figure 1.
Percent Frequency Less Than VFR by Month

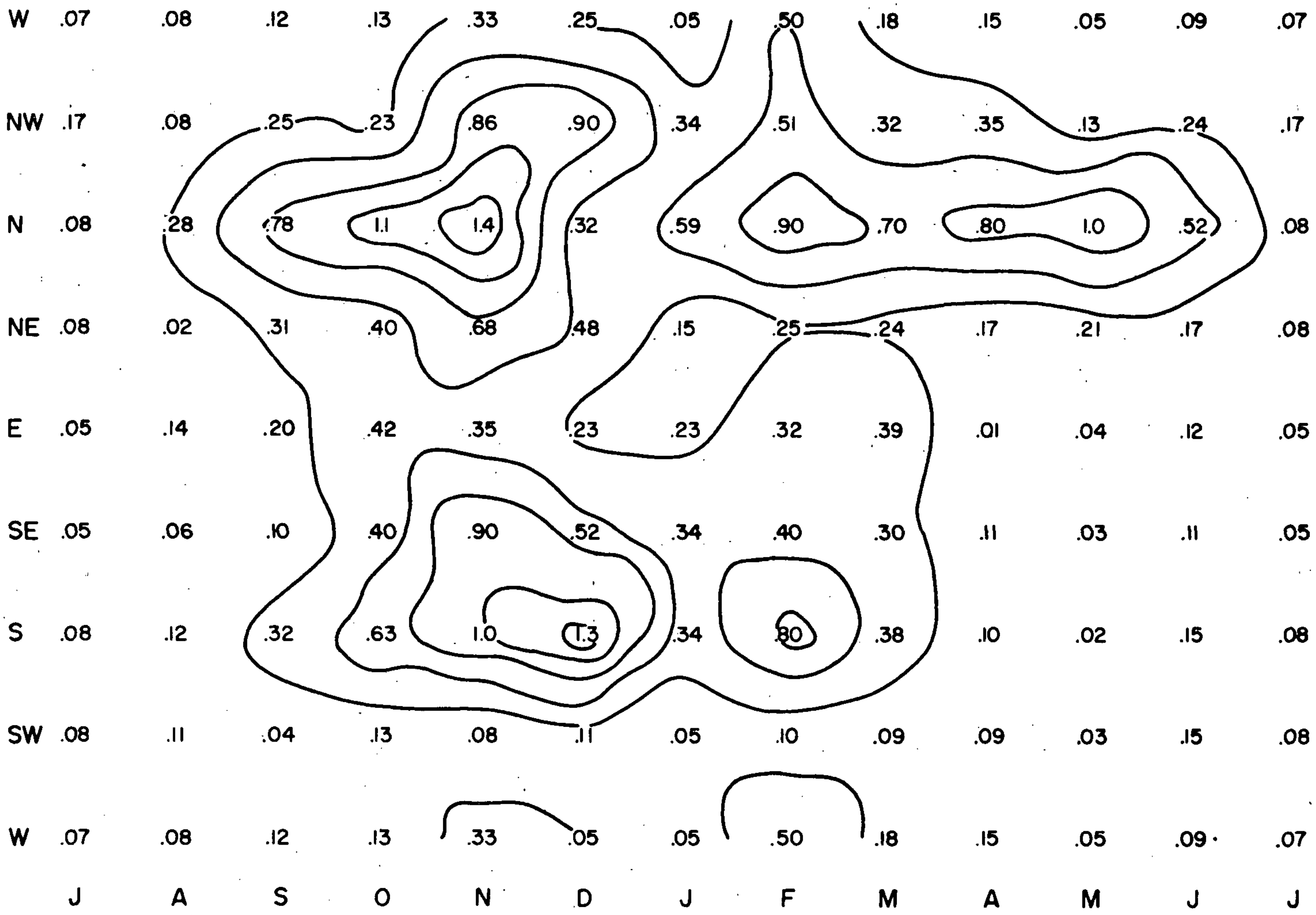

Figure 2.
Percent Frequency Less Than 500 and/or 1 by Month

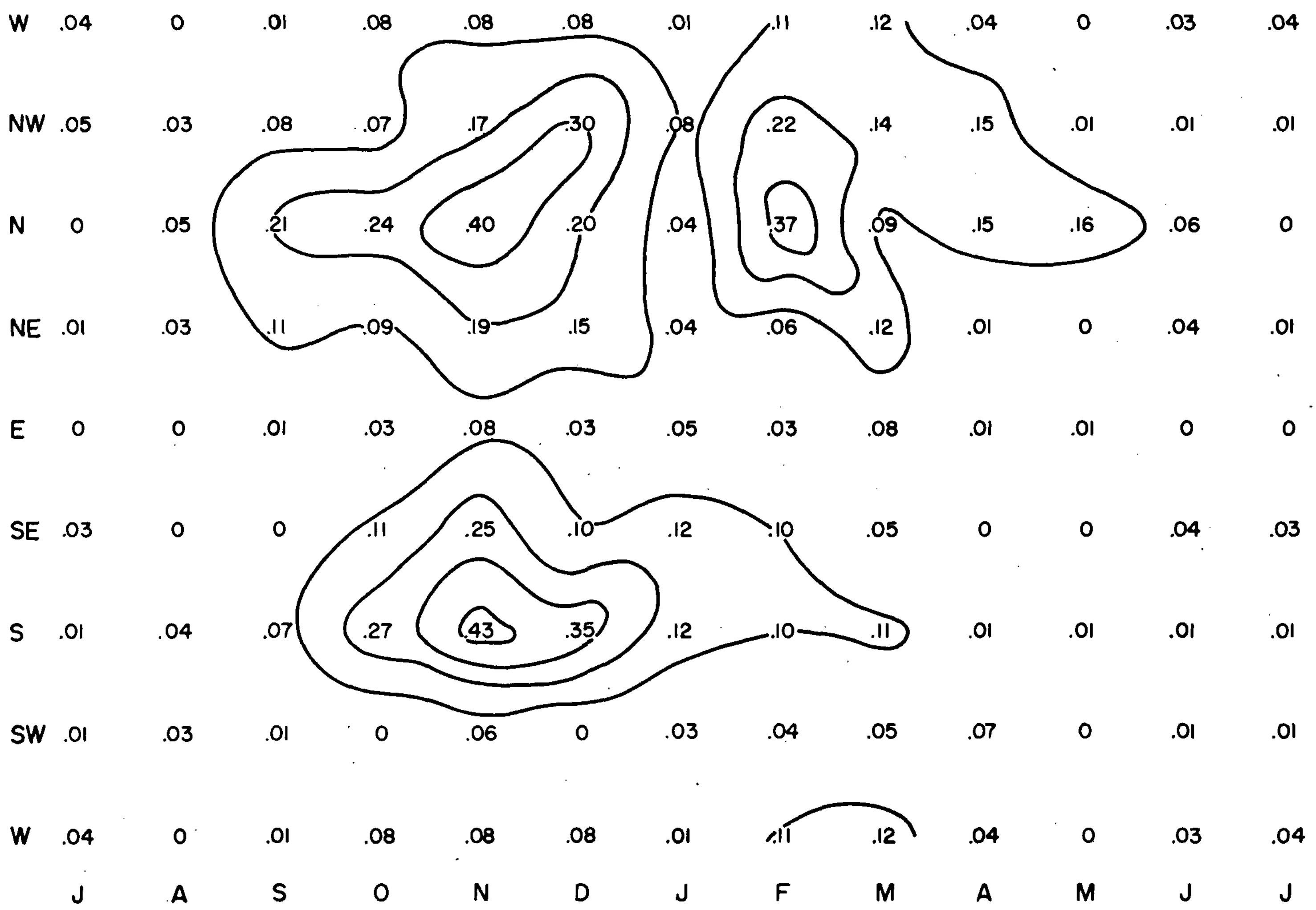

Figure 3.
Percent Frequency Less Than 200 and/or $\frac{1}{2}$ by Month

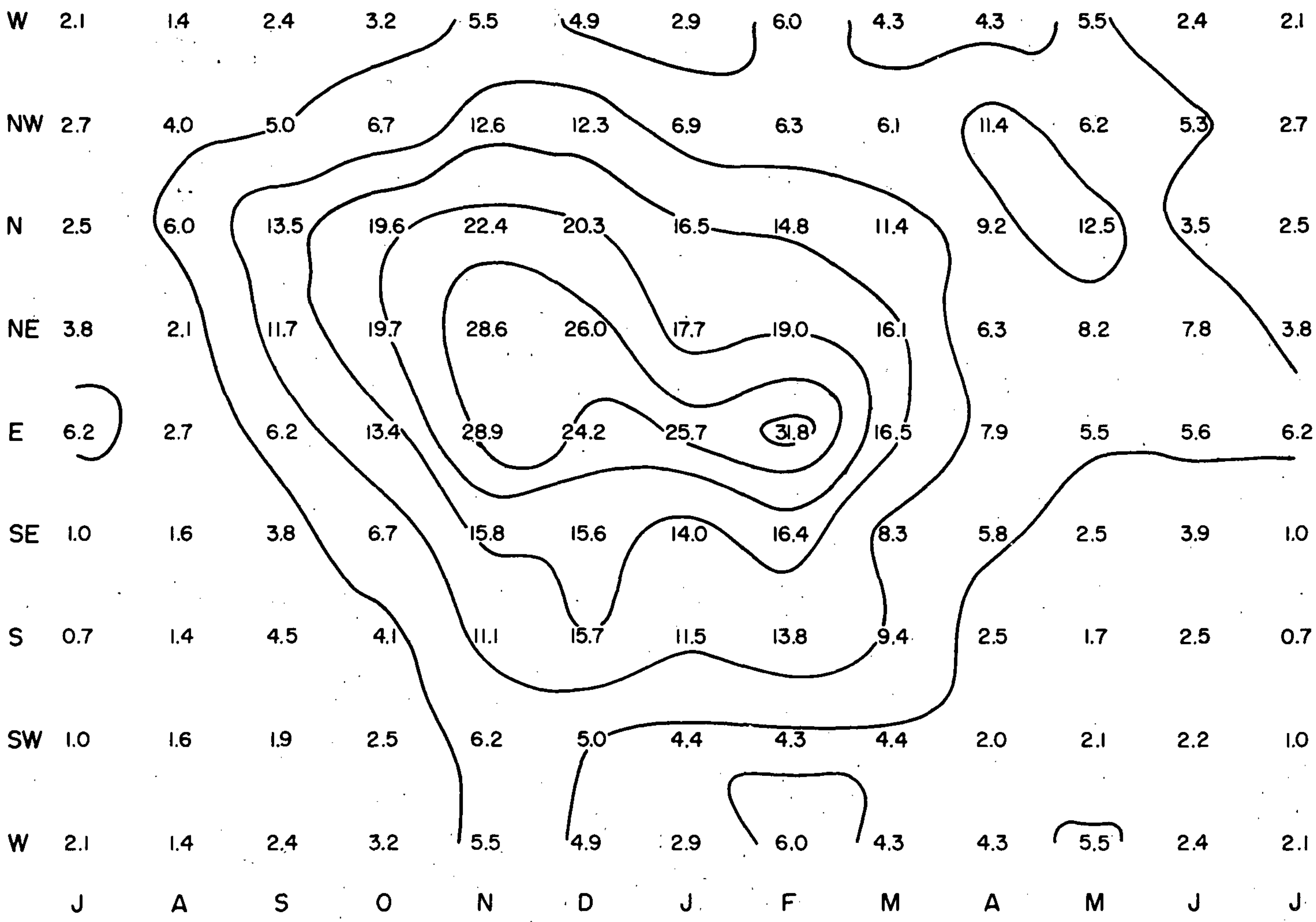

Figure 4.
Percent Frequency Less Than VFR for a Given Wind Direction in a Month

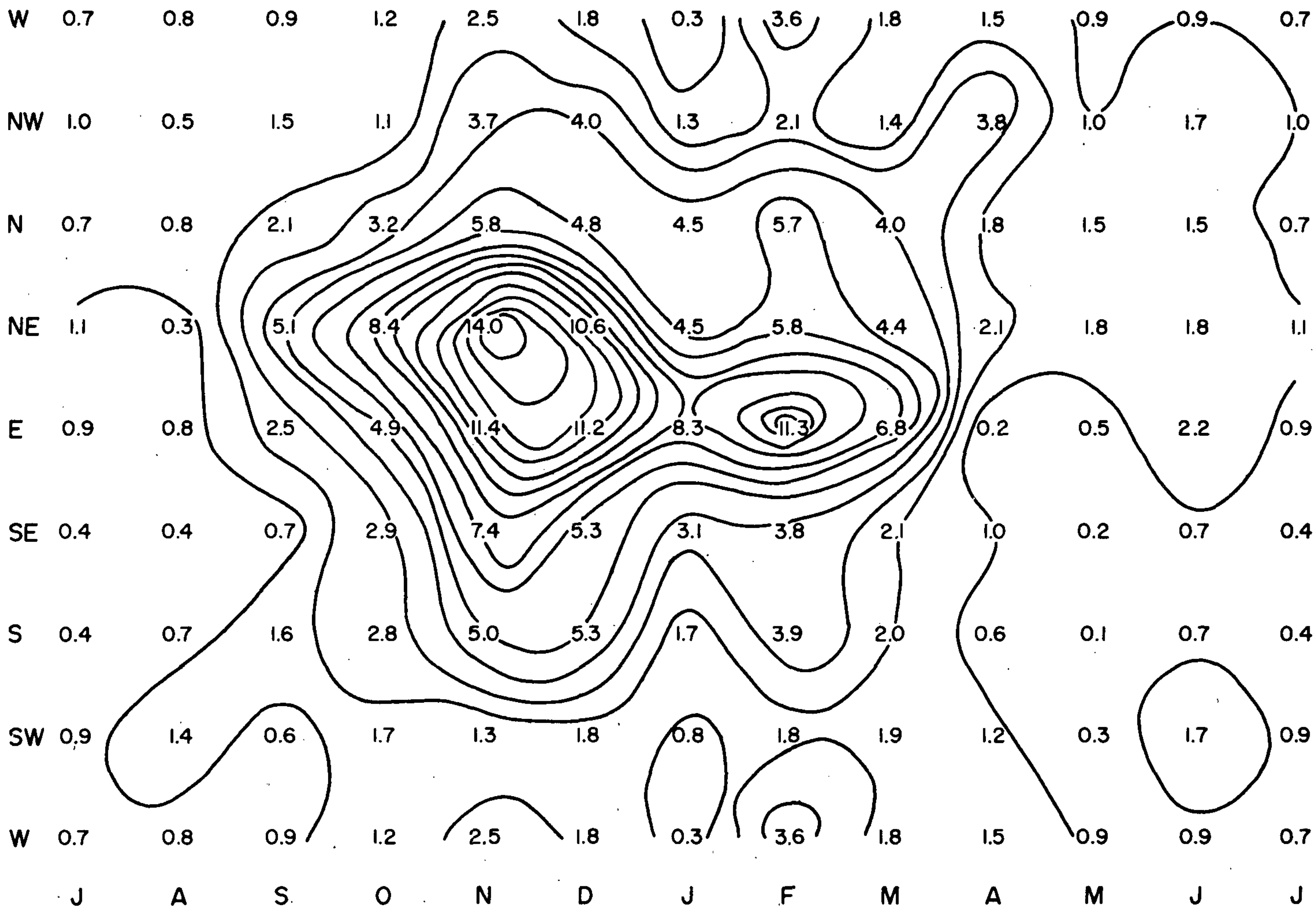

Figure 5.
Percent Frequency Less Than 500 and/or 1 for a Given Wind Direction in a Month

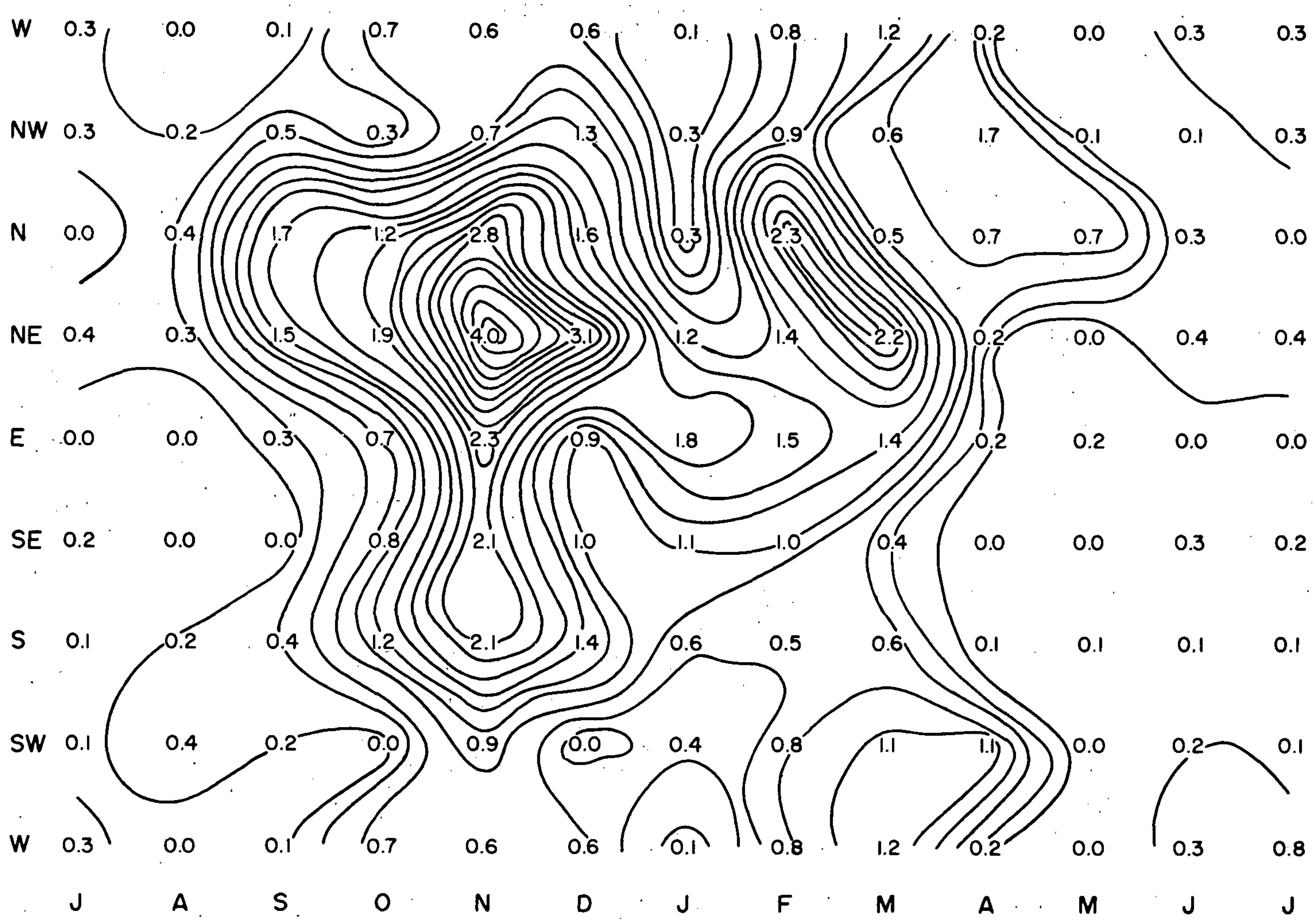

Figure 6.
Percent Frequency Less Than 200 and/or $\frac{1}{2}$ for a Given Wind Direction in a Month

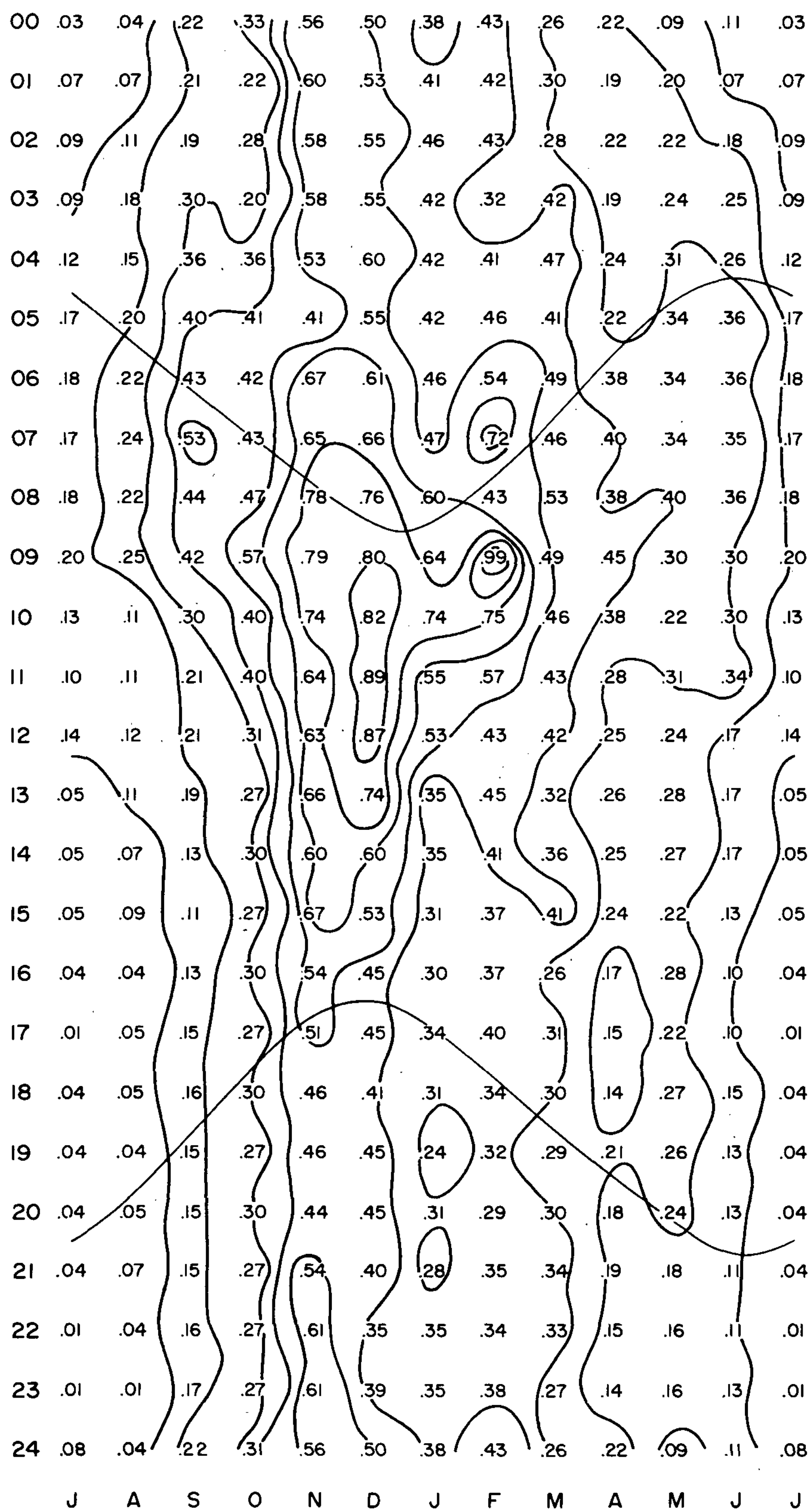

Figure 7.
Diurnal Variation of Ceilings Less Than 1000 Feet and/or Visibilities Less Than 3 Miles

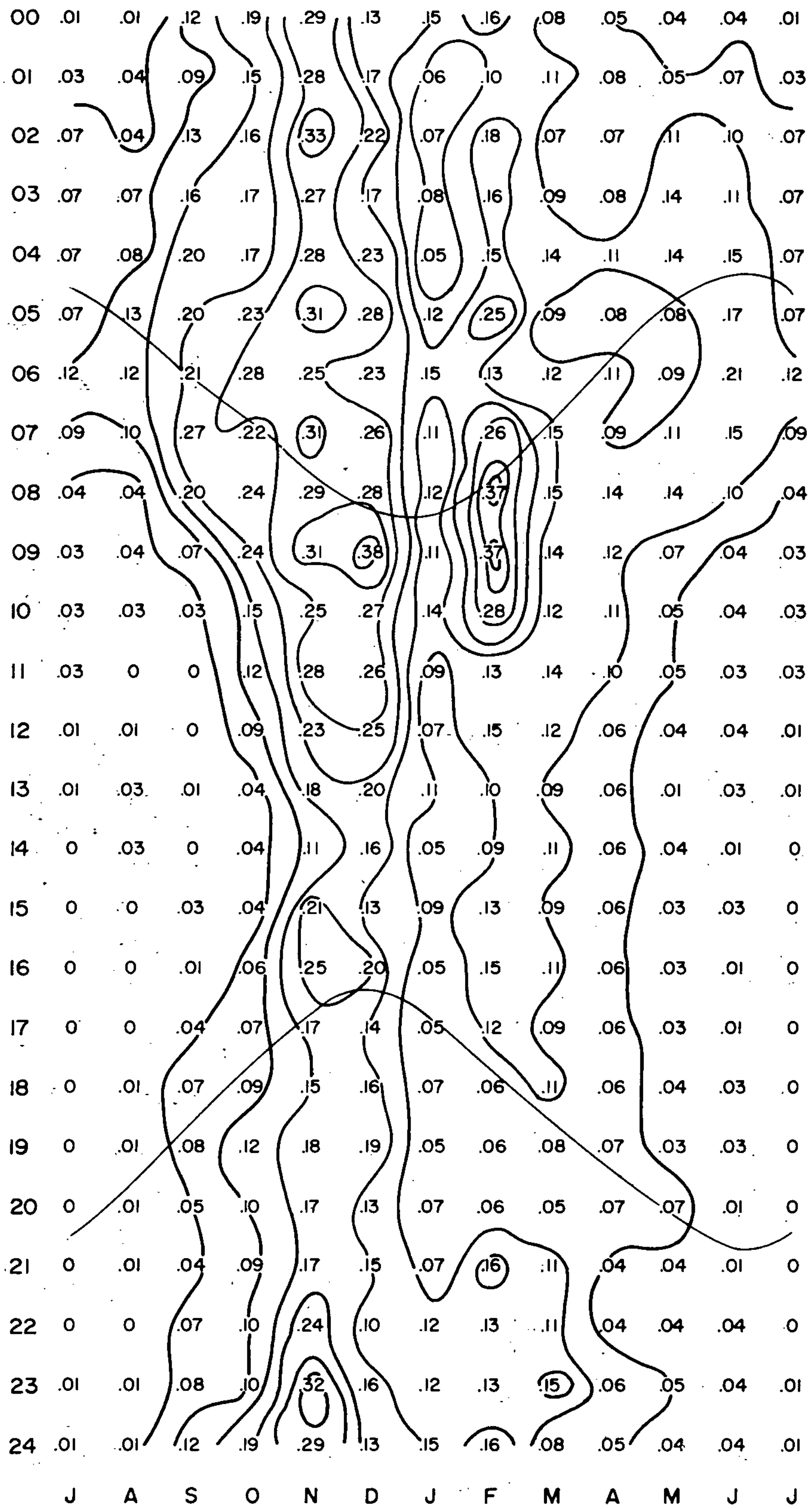

Figure 8.
Diurnal Variation of Ceilings Less Than 500 Feet and/or Visibilities Less Than 1 Mile

	J	A	S	O	N	D	J	F	M	A	M	J	J
00	0	0	.03	.05	.08	.03	.03	.02	.03	0	0	0	0
01	0	0	.06	.03	.06	.03	.03	.03	0	.01	.03	0	0
02	.01	.01	.04	.04	.01	.01	.01	.08	.01	.03	.04	0	.01
03	.03	.01	.03	.05	.08	.04	.03	.06	.01	.04	.01	.01	.03
04	.04	.05	.10	.08	.11	.07	.03	.05	.05	.03	.03	.06	.04
05	.01	.03	.07	.08	.15	.08	.03	.03	.05	.01	.01	.07	.01
06	.03	.01	.10	.11	.11	.08	.07	.03	.04	.03	.05	.07	.03
07	.03	.03	.07	.08	.13	.09	.05	.05	.09	.06	.03	.01	.03
08	.01	.03	.03	.09	.14	.06	.01	.10	.07	.04	.03	0	.01
09	0	0	.01	.12	.11	.06	.03	.10	.03	.03	.07	0	0
10	0	0	0	.03	.10	.09	.05	.10	.03	.03	.05	0	0
11	0	0	0	.01	.06	.04	.01	.03	.03	.04	.05	0	0
12	0	0	0	0	.04	.07	.01	.06	.03	.01	0	0	0
13	0	0	0	0	.03	.03	.01	.03	.03	.03	0	0	0
14	0	0	0	0	0	.01	.01	.02	.01	.01	0	0	0
15	0	0	0	0	.01	.04	.01	.03	0	.01	0	0	0
16	0	0	0	0	.03	.04	.01	.02	.03	.01	0	0	0
17	0	0	0	.01	.04	.04	.03	.02	.04	0	0	0	0
18	0	0	0	0	.03	.03	.01	.03	.05	.01	0	0	0
19	0	0	0	.03	.03	.05	.01	.02	.03	.03	0	0	0
20	0	0	0	.01	.07	.05	0	.02	0	.01	0	0	0
21	0	0	0	.04	.04	.05	0	.06	.05	.04	0	0	0
22	0	0	.01	.03	.08	.04	.05	.05	.04	.04	0	0	0
23	0	0	.03	.01	.08	.04	.01	.03	.04	.06	0	0	0
24	0	0	.03	.05	.08	.03	.03	.02	.03	0	0	0	0

Figure 9.
Diurnal Variation of Ceilings Less Than 200 Feet and/or Visibilities Less Than $\frac{1}{2}$ Mile

REFERENCES

1. Klein, William H., 1956-57: Prevailing Tracks of Lows and Highs. Weatherwise, Vol. 9, No. 3-6 incl., Vol. 10 No. 2-3.

2. J. J. Labelle, R. J. Brown and M. D. Hasinoff 1966: Climate of Winnipeg. Circ. 4437. Cli. 35.

3. A. Reimer 1958: A Study of the Occurrence of Stratus and Drizzle at Winnipeg, Sept. 6, 1957. Addendum by R. Lee, Cir. 3065, TEC-274.

4. J. Rogalsky 1964: Statistical Climatic Summaries for Aviation at Sixteen Major Canadian Airports. Cir. 4061 TEC-525.

TEC-727 UDC: 551.576.4
27 October 1969 551.591.3

CANADA

Department of Transport - Meteorological Branch
315 Bloor St., W., - Toronto 5, Ontario

Ceiling and Visibility Conditions Lower than VFR at Winnipeg Airport
by A.W. Cott

14 pps. 9 figs. 7 tables 4 refs.

Subject Reference: 1. Ceiling and Visibility.
2. Winnipeg,Manitoba.

TEC-727 UDC: 551.576.4
27 October 1969 551.591.3

CANADA

Department of Transport - Meteorological Branch
315 Bloor St., W., - Toronto 5, Ontario

Ceiling and Visibility Conditions Lower than VFR at Winnipeg Airport
by A.W. Cott

14 pps. 9 figs. 7 tables 4 refs.

Subject Reference: 1. Ceiling and Visibility.
2. Winnipeg, Manitoba.

TEC-727 UDC: 551.576.4
27 October 1969 551.591.3

CANADA

Department of Transport - Meteorological Branch
315 Bloor St., W., - Toronto 5, Ontario

Ceiling and Visibility Conditions Lower than VFR at Winnipeg Airport
by A.W. Cott

14 pps. 9 figs. 7 tables 4 refs.

Subject Reference: 1. Ceiling and Visibility.
2. Winnipeg, Manitoba.

TEC-727 UDC: 551.576.4
27 October 1969 551.591.3

CANADA

Department of Transport - Meteorological Branch
315 Bloor St., W., - Toronto 5, Ontario

Ceiling and Visibility Conditions Lower than VFR at Winnipeg Airport
by A.W. Cott

14 pps. 9 figs. 7 tables 4 refs.

Subject Reference: 1. Ceiling and Visibility.
2. Winnipeg, Manitoba.

ABSTRACT: A series of tables and diagrams showing the seasonal, wind directional and diurnal variations of below VFR weather are presented in this paper. A discussion of reasons for these variations of occurrence is included.

ABSTRACT: A series of tables and diagrams showing the seasonal, wind directional and diurnal variations of below VFR weather are presented in this paper. A discussion of reasons for these variations of occurrence is included.

ABSTRACT: A series of tables and diagrams showing the seasonal, wind directional and diurnal variations of below VFR weather are presented in this paper. A discussion of reasons for these variations of occurrence is included.

ABSTRACT: A series of tables and diagrams showing the seasonal, wind directional and diurnal variations of below VFR weather are presented in this paper. A discussion of reasons for these variations of occurrence is included.