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Report N.:



* T E C - 4 3 7 *

SKP Box Number: 672572426

CIR-3767
TEC-437
30 Nov. 62.

METEOROLOGICAL BRANCH - DEPARTMENT OF TRANSPORT - CANADA

ANNUAL AND DIURNAL VARIATIONS OF BAD FLYING

WEATHER AT GANDER, STEPHENVILLE AND TORBAY

by

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UDC: 551.575.31/2

METEOROLOGICAL BRANCH - DEPARTMENT OF TRANSPORT - CANADA

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ABSTRACT

The annual and diurnal variations of marginal and non-operational weather during a period of ten years at Gander, Torbay and Stephenville is investigated. Only those cases with ceiling \leq 200 feet and/or visibility \leq 5/8 mile in fog and/or drizzle (hereafter referred to as thick fog) are considered. The connection of thick fog with surface wind direction is also examined for each of these Airports.

INTRODUCTION

With the exception of the project completed by P. Johns (3) little has been published on the occurrences of fog at any of Newfoundland's Airports. It therefore seemed worthwhile to make an analysis of marginal and non-operational flying weather for Gander, Torbay and Stephenville.

The geographical situation of these three airports can be seen from Figure I. Stephenville and Torbay are both near the coastline, while Gander is approximately 20 miles inland. Torbay lies on the east side of the Island and projects out into the Atlantic far enough to have very little land trajectory with winds from the N through E and S to WSW directions. Winds from these directions are apt to be very moist and would be expected to bring a considerable amount of fog and low stratus to this region. Less hours of thick fog would, however, be expected at Gander with winds from these directions because of the very significant land trajectory. Stephenville lies on the west coast and would therefore expect very little thick fog with North through East winds which have to blow over the Island before reaching there.

DATA

The data for this investigation was extracted from the hourly weather reports as recorded for 1951-1960 inclusive and supplied by Climatology Division, Meteorological Branch, Department of Transport, Toronto, Ontario.

DIURNAL AND ANNUAL VARIATIONS OF THICK FOG

The procedure and tabulation of this investigation is similar to that used by N. E. Davis when dealing with fog at London Airport and by J. T. Buma when dealing with fog at Leeuwarden Airport.

The total number of occasions of thick fog were grouped according to the hour and month which they occurred and are reproduced in Table 1, Table 2 and Table 3, i.e. for Gander, Torbay and Stephenville, respectively. Each figure in the table gives the number of times in ten years that the visibility was $\leq 5/8$ mile and/or ceiling ≤ 200 feet in fog and/or drizzle for each hour of each month. The two rows at the bottom give respectively, the total number of occurrences for each month and the average number of occurrences each month. It is worth noting that these figures do not give the total number of occasions the ceiling and visibility were equal to, or less than, the prescribed values - but only when equal to or less than these values in fog and/or drizzle. During the winter months, ceiling and visibility might often be restricted to these values in snow. It will be appreciated that this investigation is concerned only with the annual and diurnal variations of thick fog.

Considering the means for each month, as given in Tables 2, 1 and 3, it is apparent that Torbay has more hours of thick fog than Gander, which in turn, has far more hours than Stephenville. The average mean, in hours per month, for Torbay, Gander and Stephenville is 116, 60 and 12 respectively.

April, May and June have the highest number of occurrences for Torbay, accounting for 38% of the total occasions for the ten years investigated. On the other hand, September, October and November are the best three consecutive months and account for only 17% of the total occurrences.

The months recording the most hours of thick fog at Gander are April, May and June, accounting for 37%; while the three consecutive months which account for the least thick fog are July, August and September, with 17%.

June, July and August account for 35% at Stephenville, while December, January and February account for only 6% of the total occurrences of thick fog.

Figures 2, 4 and 3 are isopleth reproductions of the figures presented in Tables 1, 2 and 3 respectively.

The most significant features in the variation of thick fog, as seen from Figure 2 for Gander Airport, appears to be as follows:

1. Little diurnal effect on occurrences of thick fog in January - although the maximum does occur in the early morning hours, there are very few less occurrences in midafternoon.
2. February and March each has approximately the same number of occurrences as January, but the diurnal effect is greater - there is a slow improvement after sunrise and this improvement is more pronounced in March than in February.
3. The rapid increase in the number of occurrences in April, May and June, especially between 2300Z and 0900Z. These months show a high maximum at sunrise.
4. The increasing tendency for conditions to improve immediately after sunrise during April, May and June.

5. The decrease in the number of occurrences during July, August and September.
6. The few occurrences around mid-day during June, July, August and September - which months show rapid improvement shortly after sunrise and this improvement persists until nearly sunset.
7. The tendency for the number of occurrences to increase during October, November and December and persist throughout the day.

The most significant features in the variation of thick fog as seen from Figure 4 for Torbay Airport appear to be as follows:

1. The tendency of the occurrences for January, February and March, which are approximately equal, to persist all day - thus showing very little diurnal variation: but there is an increasing tendency for improvement to occur around mid-day in March.
2. The strong tendency for the number of occasions to increase during April, May and June, after 2200Z and reaching a peak around 0800Z. The highest number of occurrences is in May during the hours prior to sunrise.
3. April, May and June show a stronger tendency for improvement in the hours immediately following sunrise than was evident during January, February and March.
4. There is a decreasing tendency in the number of occurrences during July, August and September. Improvement is rapid during the hours immediately following sunrise and by mid-afternoon the percentage of improvement is considerably higher than during any previous month.
5. The afternoons of July and September show a low minimum.
6. October, November and December show an increase in the number of occurrences and there is a decreasing tendency for midday clearing.

The most significant features in the variation of thick fog as seen from Figure 3 for Stephenville Airport appear to be as follows:

1. Low fog frequency in January, February and March with an average monthly mean of 2.6 occurrences. No diurnal trend is evident.

2. The tendency for the number of occurrences to increase during April to August. A diurnal trend is evident during May and June - during July it is pronounced with a high maximum just before sunrise. The diurnal trend is considerably less during April and August.
3. The number of occurrences decrease from September to December. Here again diurnal trends do not appear to exist.

From an examination of these significant factors and Table 4 which contains the time of the maximum occurrence and sunrise for each month, it is evident that Gander and Torbay show similar diurnal and annual variations in thick fog. Each has its high maximum of occurrence in May, which is followed in turn by June and then April; while each has its minimum number of monthly occurrences during September. Diurnal trends are also similar - pronounced during the summer and decreasing during the fall and spring months and reaching a minimum during December, January and February.

No such clear cut division is possible for Stephenville. Diurnal trends in thick fog are not evident for most months and are very weak for those months in which they do occur. Fog is most prevalent during the spring and summer months, with the maximum number of occasions being in July. This deviation from the normal, as was concluded to exist for Torbay and Gander, may be due primarily to the very few occasions of thick fog which occur at Stephenville. The most significant factor for Stephenville is that so few cases did occur during the ten year period investigated.

CONNECTION WITH SURFACE WIND DIRECTION

The relationship between thick fog frequency and surface wind direction was investigated by choosing wind directions to the nearest of eight points to the compass and counting the number of hourly observations of thick fog corresponding to each given wind direction. The result of the ten year period, 1951-1960, is given in Table 5 and Figure 5. NNE winds are grouped as North Winds. ENE as NE, etc.

Surface Wind Direction	No. of hrs. of thick fog at Gander with each wind direction.	No. of hrs. of wind at Gander from each direction	% of time thick fog at Gander with each wind direction.	Hrs. of fog with each wind direction at Stephenville.	Hrs. of fog with each wind direction at Torbay.
Calm	866			366	426
N-NNE (N)	1125	8606	14.0%	7	2335
NE-ENE (NE)	719	5701	12.6%	31	2449
E-ESE (E)	1678	6402	26.2%	14	1914
SE-SSE (SE)	915	9493	9.6%	8	2726
S-SSW (S)	132	10004	1.3%	47	1399
SW-WSW (SW)	77	23128	.3%	571	896
W-WNW (W)	243	16840	1.4%	159	809
NW-NNW (NW)	1471	13231	11.1%	5	588

TABLE 5

Wind Directions with Thick Fog at Gander, Stephenville and Torbay.

Table 5 also includes the number of occasions the wind was from each direction at Gander during the ten year period and the percentage of time that these winds were accompanied with thick fog. Although Gander has fewer cases of thick fog with North East winds than with North winds, Table 5 shows that when percentage frequency of occasions with given wind direction are taken into consideration, thick fog is equally probable with one wind direction as the other. According to Johns (3), winds from the North are affected by a gradual upslope, while to the NE of Gander the land rises abruptly from the sea and then the terrain is fairly level to Gander. This may explain the small deviation in percentage frequency of thick fog with winds from North and North East directions.

The percentage frequency of fog increases with an East wind; this can generally be attributed to the surrounding influences. Both North and North-East winds, whether from a cyclonic flow, or anti-cyclonic flow, blow off the cold water of the Atlantic. These winds are not warmed by the Gulf Stream. Although they are very moist, these winds will generally not produce fog until the air is forced to cool. Since the temperature of the coastline is approximately equal to the temperature of the water from which these winds blow, most of the fog will be in the higher region. Since the environment around Torbay is higher above sea level than Gander, it would have more occurrence of thick fog with these winds.

On the other hand, winds from the East and South East, whether they are from a cyclonic or anti-cyclonic flow, are warmed by the Gulf Stream. As these warm moisture laden winds approach Newfoundland's eastern coastline they are cooled by the Labrador current and produce fog even before the coastline is reached. This fog is then advected inland and with an East wind gives Gander a high percentage frequency of thick fog. Southerly winds also bring fog to the coast because of the warming effects of the Gulf Stream followed by the cooling effects of the waters around the coast. But these winds bring less thick fog to Gander than an East wind. This is so because of the hills to the South East, South and South West of Gander. As this moisture laden air is pushed over this high ground, it is cooled and loses some of its moisture. The downslope effect to Gander causes the ceiling to be higher than would normally be the case if it was higher above sea level.

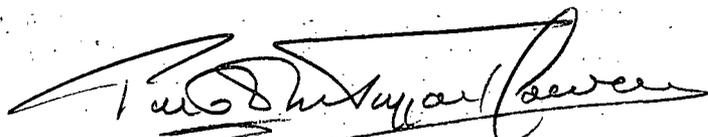
Torbay, however, is not as protected as is Gander from thick fog with these wind directions. South East winds blow directly off the sea and give Torbay a high percentage frequency of thick fog. As the winds veer to the South and South-West, Torbay receives protection from the land mass of the Avalon Peninsula, but even then the land trajectory is fairly short and it receives a considerable amount of thick fog.

Stephenville, on the other hand, is protected by both the surrounding mountain range and the long land trajectory and therefore receives very little thick fog with winds from the North-West to South directions. However, it is not protected in a South-West wind and with this wind receives most of its fog. Westerly winds which blow over the warm water of the Gulf are not forced to cool before reaching Stephenville and therefore bring very little thick fog to its locality. If Stephenville were not situated at sea level but in the surrounding mountains, it is expected that thick fog with Westerly winds would be more prevalent.

Torbay receives less fog with West and North West winds than with any other wind direction but with even these winds, a considerable amount of thick fog occurs. This can chiefly be attributed to the cold waters of Conception Bay. Since these waters are usually colder than the surrounding area, fog tends to form in the Bay and with a West and North-West wind is pushed towards Torbay.

To summarize, from an aircraft operational point of view, Stephenville is a dependable airport. It is very unlikely that aircraft using this terminal will be seriously hampered during any month of the year because of prolonged periods of thick fog. Torbay, on the other hand, is apt to be a problem for scheduled aircraft, especially during the early hours of the morning, during April, May and June. Gander will also provide its problems. This will be true especially in the early morning hours of the spring months but should be very suitable for daily operations during the summer and fall months.

APPROVED,



P. D. McTaggart-Cowan,
Director.

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Met. Mag., London, 80, 1951, page 9
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Cir - 2559, 19 Nov 1954.

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Time	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
G.M.T.	Number of occasions ceiling 200 ft. and/or visibility 5/8 mi. from 1951 - 1960 incl.											
0000	32	24	21	36	47	33	20	19	13	28	27	13
0100	35	27	23	39	53	49	25	22	12	22	25	13
0200	38	26	23	43	57	58	26	28	14	28	27	16
0300	36	25	24	40	68	67	30	38	18	25	27	13
0400	33	28	29	42	67	69	34	36	17	30	23	14
0500	31	32	27	41	68	78	33	38	18	32	28	12
1600	30	33	30	43	72	79	35	38	20	31	24	15
0700	29	32	30	43	73	73	37	39	20	36	31	11
0800	38	31	27	40	73	73	38	46	17	39	29	11
0900	29	36	29	42	61	57	32	52	20	42	28	10
1000	35	31	28	39	51	41	32	40	19	34	30	12
1100	34	34	32	40	47	30	34	29	18	32	33	17
1200	34	25	25	32	45	20	16	21	8	24	34	11
1300	30	22	23	26	34	14	11	12	8	17	24	14
1400	29	20	22	22	32	11	8	10	5	15	20	13
1500	25	18	17	18	28	6	6	3	4	10	15	10
1600	24	18	13	19	12	7	2	4	3	8	18	12
1700	24	16	13	15	13	7	2	7	2	4	14	10
1800	22	17	9	14	12	7	3	5	3	7	14	7
1900	24	19	11	17	16	9	4	4	4	11	16	11
2000	29	18	12	25	22	9	5	4	1	10	23	16
2100	28	18	14	27	25	13	5	11	4	14	24	19
2200	35	25	14	28	27	20	9	12	9	22	27	17
2300	30	26	23	35	37	24	13	17	10	23	27	12
Total	721	596	519	768	1040	897	450	535	267	544	586	309
Mean	72.1	59.6	51.9	76.8	104.0	89.7	45.0	53.5	26.7	54.4	58.6	30.9

TABLE I

Annual and Diurnal Variations of Bad Weather Flying
Conditions in Fog and Drizzle at Gander Airport.

Time	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
G.M.T.	Number of occasions ceiling < 400 ft. and/or visibility < 5/8 mi. from 1951 - 1960 incl.											
0000	48	46	41	71	90	68	51	45	33	34	27	33
0100	50	52	43	72	102	75	49	43	31	37	35	31
0200	44	41	47	65	94	82	64	52	30	31	36	33
0300	47	44	53	70	101	81	74	52	36	43	36	28
0400	47	42	45	71	108	91	81	55	38	40	42	27
0500	52	41	49	70	115	97	84	58	36	41	43	31
0600	47	39	53	75	116	97	89	60	36	42	49	26
0700	46	41	52	76	116	103	75	57	33	40	45	28
0800	48	41	53	81	115	99	75	56	31	40	44	27
0900	48	37	57	72	113	97	71	68	31	41	46	25
1000	58	38	58	62	100	79	63	58	29	40	45	24
1100	49	41	46	66	90	60	41	46	28	44	44	27
1200	50	41	44	60	70	51	29	37	21	36	43	29
1300	46	36	39	57	62	50	27	28	23	33	42	27
1400	46	32	39	57	58	39	27	26	20	33	36	26
1500	51	34	35	52	56	37	17	22	16	29	33	29
1600	48	32	40	47	58	31	17	24	15	29	36	26
1700	45	37	35	40	60	33	20	23	13	32	29	27
1800	48	41	38	44	56	39	21	25	19	29	28	30
1900	47	42	39	44	62	42	24	24	19	28	26	37
2000	50	46	41	50	64	39	24	24	20	27	33	36
2100	54	46	42	54	71	46	25	28	18	26	36	40
2200	47	48	39	60	78	49	33	32	28	32	37	35
2300	46	45	42	66	89	60	40	36	36	37	37	36
Total	1166	993	1070	1482	2044	1545	1121	979	640	844	898	719
Mean (hr/mo)	116.6	99.3	107.0	148.2	204.4	154.5	112.1	97.9	64.0	84.4	89.8	71.9

TABLE 2

Annual and Diurnal Variation of Bad Weather Flying
Conditions in Fog and Drizzle at Torbay Airport.

Time	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
G.M.T.	Number of occasions ceiling < 200 ft. and/or visibility < 5/8 mi. from 1951 - 1960 incl.											
0000	1	-	-	5	9	10	13	11	5	3	6	2
0100	1	-	-	7	11	10	12	9	6	5	5	2
0200	1	-	3	6	7	12	9	7	5	5	5	1
0300	2	2	3	7	6	14	8	8	4	4	3	1
0400	1	-	2	10	5	13	11	9	4	5	3	-
0500	4	-	2	10	4	9	10	7	4	2	4	2
0600	2	-	2	7	4	9	11	2	4	3	2	1
0700	1	-	-	6	5	13	11	2	6	3	2	-
0800	3	-	-	5	4	7	14	5	8	2	3	-
0900	1	-	1	8	4	12	12	5	9	1	2	-
1000	-	1	1	6	4	9	10	3	5	3	2	-
1100	2	-	-	6	1	8	7	2	6	5	2	-
1200	3	1	-	12	2	11	7	10	3	7	4	-
1300	2	1	-	7	4	6	6	4	2	3	2	-
1400	2	1	-	5	2	5	4	3	4	2	3	2
1500	1	2	-	2	-	4	5	4	3	2	4	3
1600	2	2	1	1	2	5	7	5	3	2	3	1
1700	1	-	-	1	3	8	3	6	4	3	2	1
1800	1	1	1	4	1	6	6	8	4	2	3	2
1900	2	-	2	3	4	7	10	9	3	3	1	2
2000	3	1	1	4	5	11	13	9	2	5	1	2
2100	3	1	2	6	7	9	15	8	6	4	3	2
2200	3	1	1	5	6	13	12	9	5	5	4	3
2300	-	-	1	4	5	7	8	6	6	2	3	-
Total	42	14	23	137	105	218	224	151	116	81	72	27
Mean	4.2	1.4	2.3	13.7	10.5	21.8	22.4	15.1	11.6	8.1	7.2	2.7

TABLE 3

Annual and Diurnal Variation of Bad Weather Flying Condition in Fog and Drizzle at Stephenville Airport.

Month	Sunrise	Time of maximum occurrence		
		Gander	Stephenville	Torbay
January	1400Z	0200Z	0500Z	1000Z
February	1040Z	0900Z	03, 15 & 1600Z	2200Z & 1000Z
March	1000Z	1100Z	0200Z & 0300Z	1000Z
April	0900Z	0800Z	1200Z	0800Z
May	0800Z	0700Z & 0800Z	0100Z	0600Z & 0700Z
June	0730Z	0700Z	0300Z	0700Z
July	0800Z	0800Z	2100Z	0600Z
August	0840Z	0900Z	0000Z	0900Z
September	0930Z	06Z, 07Z & 0800Z	0900Z	0400Z
October	1000Z	0900Z	1200Z	1100Z
November	1040Z	1200Z	0000Z	0600Z
December	1040Z	1100Z	1400Z	2100Z

TABLE 4

Time of Sunrise and Maximum Occurrence of Thick Fog for
Gander, Stephenville and Torbay.

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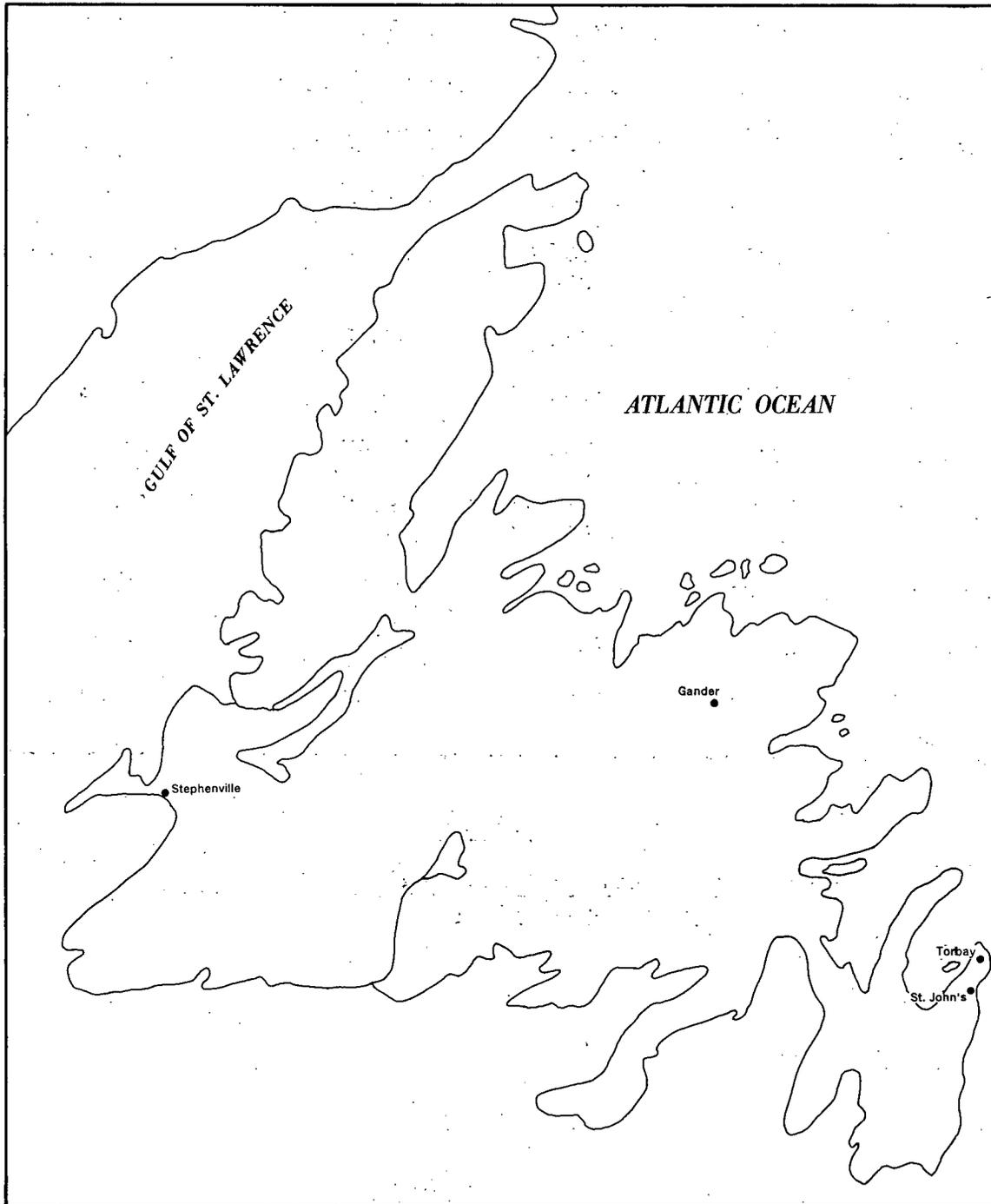


Fig. 1

MAP SHOWING THE LOCATION OF GANDER, STEPHENVILLE AND TORBAY

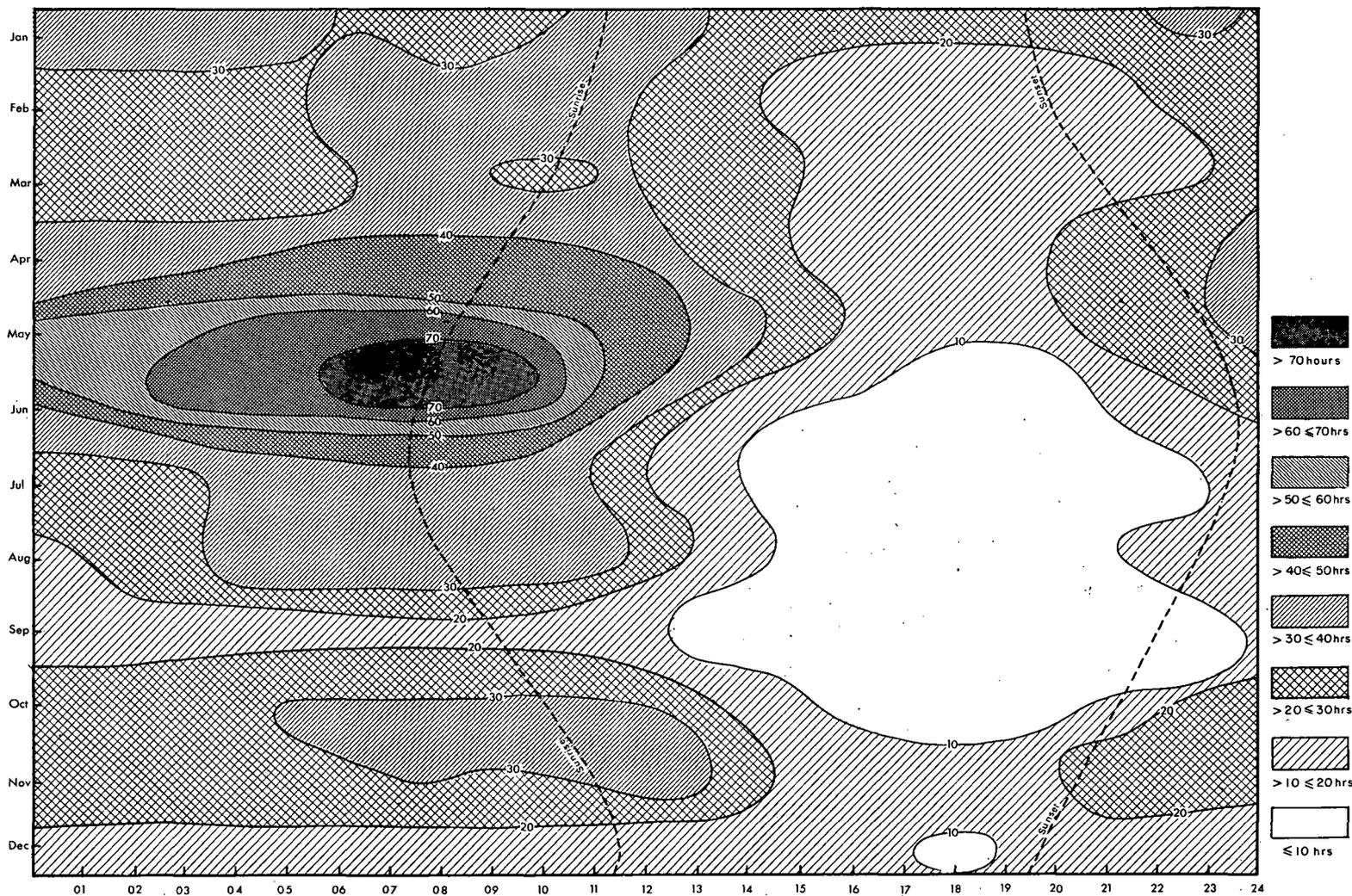


Fig. 2

Annual and Diurnal Variation of Bad Weather Flying
Conditions in Fog and Drizzle at Gander.

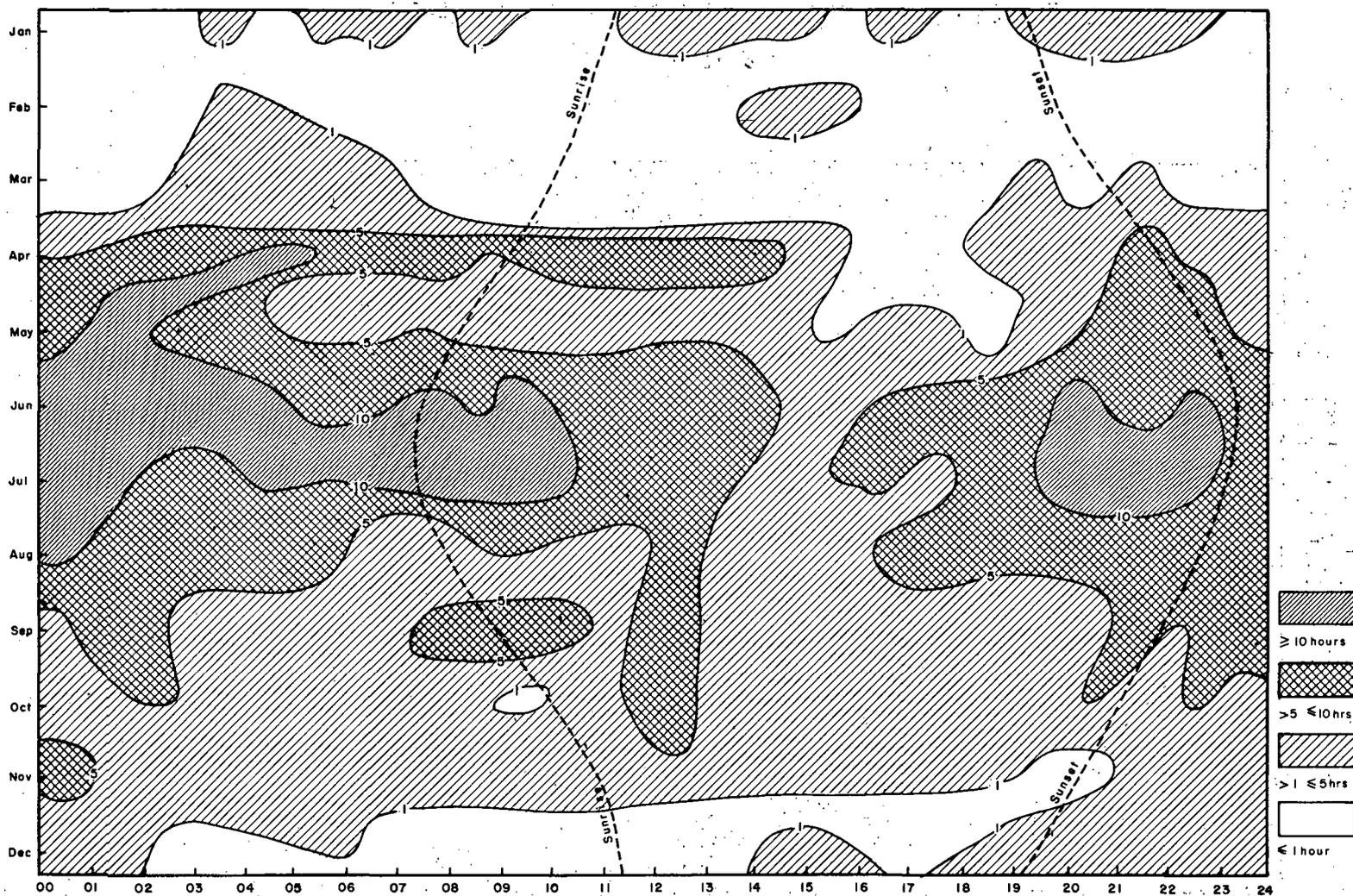


Fig. 3

Annual and Diurnal Variation of Bad Weather Flying
Conditions in Fog and Drizzle at Stephenville.

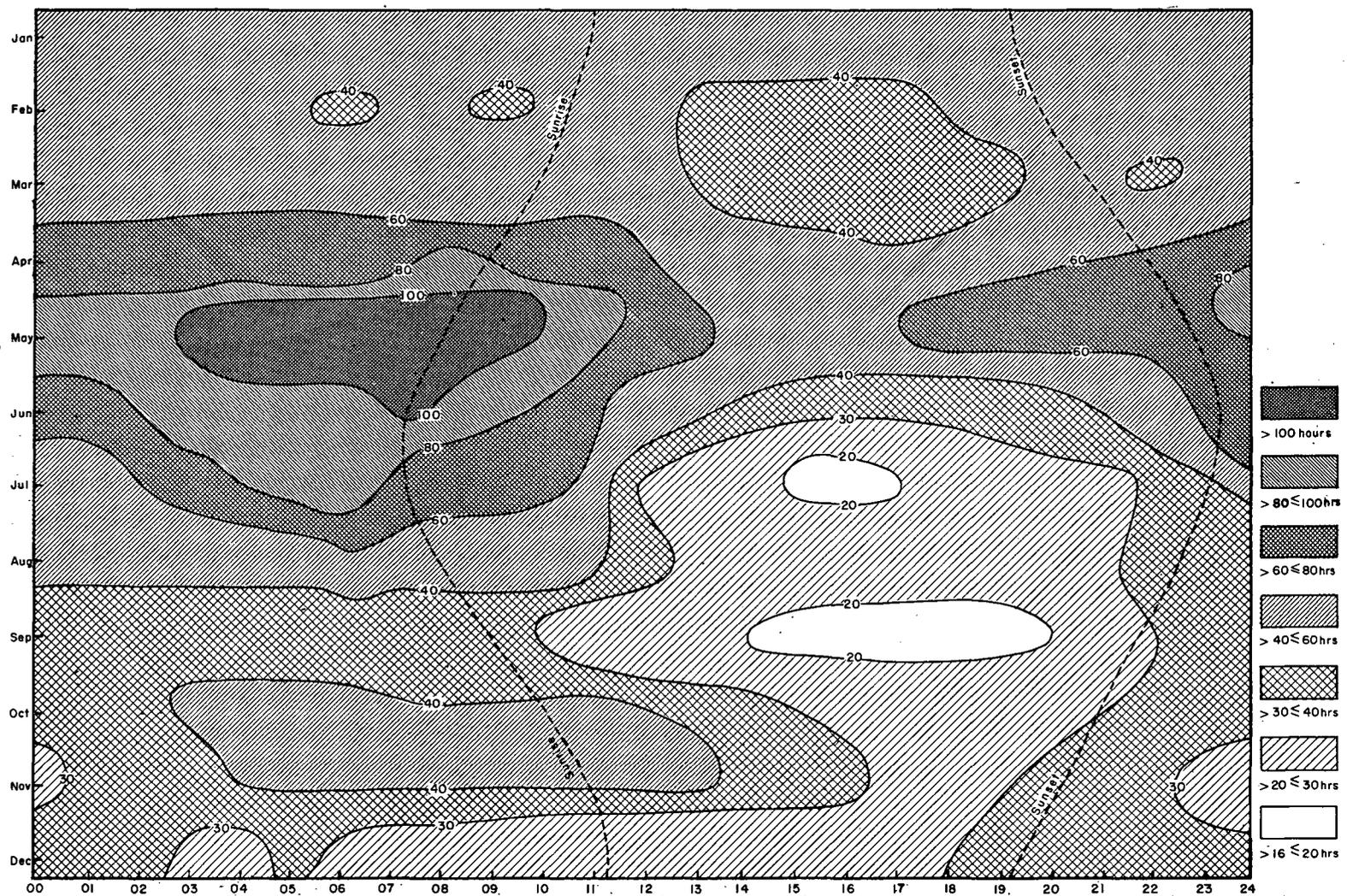


Fig. 4

Annual and Diurnal Variation of Bad Weather Flying Conditions in Fog and Drizzle at Torbay.

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CIR-3767
TEC-437
30 Nov. 62.

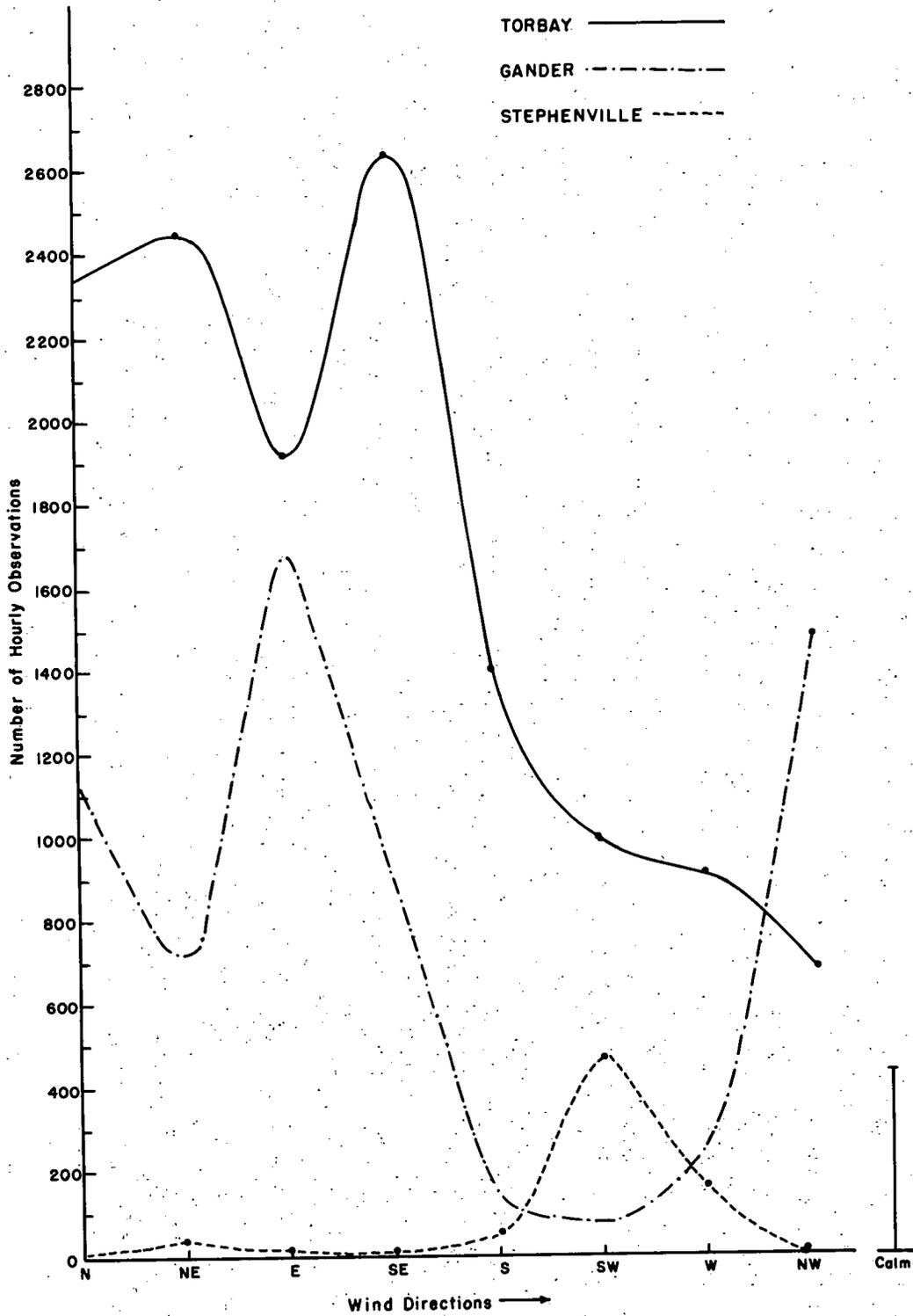


Fig. 5

Frequency Distribution of the Surface
Wind Direction During Thick Fog