Bermuda Meteorological Station

No. 2

Gales in Bermuda

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by

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CONTENTS

15 yrs.

GALES IN BERMUDA

SUMMARY

The gales recorded by a Dines anemometer at Fort George from 1932 to 1947 are analysed.

There is a marked maximum frequency in January and February. February is the worst month with, on the average, 63 hours of gale falling on 8 days. The other winter months from November to March, have 4 to 7 gale days, while the summer months have less than one gale day each, with the minimum in July, which had only one gale in the 15 years.

West and North-west, with 27 gales a year, are the most frequent directions, and North-east to East the least frequent, with less than 3 per year.

The average gale blows for four hours, but more than 10 hours has been recorded from all directions and over 70 hours from North-west. This North-westerly extreme was immediately preceded by South-westerly to Westerly gales, making over 81 hours of continuous gale.

The usual maximum speed in gales varies little with direction or month, the average maximum steady speed being about 45 m.p.h., and the average maximum gust slightly over 60 m.p.h.

Winds over 50 m.p.h., have blown from all directions and in all months except May and July. Speeds of 60 or over have been recorded from all directions except North-east and East, and in all months except May, June, July and September. Gusts over 80 have been recorded from all directions, and over 75 in all months except May and July.

In Tropical Depressions steady winds of 100 m.p.h. with gusts over 130 have been observed.

Tropical storms cause 80% of the gales in July, August and September, while from December to March gales are due entirely to frontal disturbances of extra tropical origin.

INTRODUCTION

Bermuda is situated approximately 32° N 65° W in a position such that it is on the North-western end of the subtropical anticyclone referred to variously as the Bermuda or Azores high. During the winter this anticyclone is sufficiently far to the South-east for most of the fronts which move off the American continent to cross Bermuda, and gales or strong winds are often experienced with these fronts. In the summer the anticyclone extends further to the North and West, and few fronts pass over the islands. Those which do are more marked by cloud and precipitation than by strong winds. When gales are experienced in the summer they are usually due to tropical disturbances, but it is unusual for tropical disturbances to come close enough to Bermuda to give a wind of gale force.

Observations of wind with a Dines Anemometer began on 1st August, 1932, and it is the purpose of this note to summarize the data on gales available for the 15 years until the end of July, 1947.

2. SITE

The Bermuda Government Observing Station is situated on Fort George Hill, St. George's. This is a steep sided hill rising from the harbour to a height of about 170 feet. The fort is a three-storey building 60 feet square, sunk in the ground so that its top is only 9 feet above ground level. It is surrounded by a moat 22 feet wide and the full depth of the building. There is a 9-foot wide parapet rising 5 feet above the roof, and the anemometer is erected in the centre of the western side. In the North-west corner of the roof is the signal lookout, some 14 feet high and 12 feet square. The anemometer head is 40 feet above the parapet and thus 31 feet higher than this room and 222 feet above M.S.L. The hill falls away very steeply to the South, less steeply to the North and West, and to the East, although at first it falls away very steeply, there are other lower hills within ¼ to ¾ of a mile.

The sea coast is 500 yards away to the North-west, and St. George Harbour 250 yards to the South-east.

The anemometer is, therefore, freely exposed, with a possibility that it is over-exposed, especially towards the North and North-west, but the results are considered to be representative of the wind over the open sea at an effective anemometer height of rather more than the standard 10 metres.

3. DAILY MAXIMUM WIND SPEED AND GUST

Before proceeding to analyse the gales it is of interest to consider the maximum winds recorded every day. This has been done by counting the days when the maximum wind fell within the limits 0-9, 10-19, etc. m.p.h., and then computing the percentage frequency of each group. The values for each month are given in Table 1 together with the average daily maximum calculated from the percentages and mean of each group. The daily maximum was taken as the highest steady speed maintained for 10 minutes.

Month	0-9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100-9	Mean Daily Max.
January.....	2.4	22.8	37.6	24.7	8.8	3.0	0.6					27
February...	0.5	13.5	28.8	32.4	17.0	6.6	1.2					32
March.....	1.1	23.0	40.6	23.9	9.9	1.1	0.2	0.2				27
April.....	2.2	28.6	46.4	15.4	5.8	1.3	—	—	—	0.2		24
May.....	4.7	48.2	37.2	9.0	0.9							20
June.....	8.7	53.1	31.6	5.6	0.7	0.4						18
July.....	6.2	59.1	30.5	3.9	0.2							18
August.....	9.1	54.5	29.1	5.4	1.3	0.4	0.2					18
Setptember	10.9	46.4	30.7	10.0	1.6	0.4						19
October.....	3.0	36.6	39.8	13.3	4.9	2.2	—	—	—	—	0.2	23
November.	2.9	24.2	39.6	24.0	7.8	1.3	0.2					26
December..	1.1	23.0	32.0	24.9	15.9	2.6	0.4					29

TABLE 1. Percentage of Days with Maximum Daily Wind Speed in limits given (m.p.h.)

It is seen that February has the highest average daily maximum of 32, with a maximum of 30 to 39 m.p.h. on almost one day in three.

In June, July and August the maximum wind is less than 20 m.p.h. on more than 60% of the days, and on more than 50% of the days in May and September. In all these five months the range from 10-19 m.p.h. has the greatest frequency. The remaining six months are intermediate between the February maximum and the summer minimum, with 20-29 m.p.h. the most frequent daily maximum.

The frequency of days with strong winds, that is of 30 m.p.h. and over, varies from the winter maximum in February where more than half the days have winds of this speed, to the summer minimum in July when 4% of the days have a strong wind. Similarly, the frequency of days with gales, which agrees closely with that of days with 40 m.p.h. and more, has a maximum of 25% in February and a minimum of 0.2% in July.

Table 2, which gives data relative to the maximum daily gust, shows the same general effects as Table 1.

Month	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	130–9	Mean Daily Max.
January	—	6.0	20.9	25.2	22.6	14.2	7.5	1.3	1.9	0.4	—	40
February	—	3.8	14.0	19.1	26.2	19.1	11.8	3.3	2.4	0.2	—	45
March	0.2	4.5	22.4	30.8	20.9	12.7	6.7	1.3	0.4	0.2	—	39
April	0.2	10.7	26.3	29.2	19.6	8.9	3.1	1.1	0.4	—	0.2	35
May	0.6	21.5	35.3	28.6	10.3	2.6	0.9	0.2	—	—	—	28
June	1.3	25.6	40.7	22.0	7.3	2.0	0.7	0.4	—	—	—	26
July	0.4	23.7	46.0	20.0	8.0	1.5	0.4	—	—	—	—	26
August	0.6	29.7	37.7	20.9	7.1	2.6	0.4	0.4	0.4	—	—	26
September	1.6	25.3	33.1	22.4	11.3	4.4	1.3	0.4	—	—	—	28
October	1.3	14.8	33.1	27.5	15.3	3.9	2.2	1.7	—	—	0.2	32
November	1.1	8.9	26.0	30.4	18.9	9.3	4.4	0.7	—	0.2	—	35
December	0.4	6.7	22.2	24.1	22.8	15.5	6.0	1.7	0.6	—	—	40

TABLE 2. Percentage of Days with Maximum Gust in limits stated. (m.p.h.)

The average daily gust varies from 45 m.p.h. in February to 26 in June, July and August. The most frequent daily maximum is 20-29 m.p.h. in the six months, May to October, 40-49 in February and 30-39 in the remaining five months.

In February 5 days have gusts reaching 60 m.p.h. and the seven months, October to April, each average at least one day per month with gusts of this speed.

In both tables 1 and 2 the extreme high values shown in April and October were due to Tropical Depressions.

4. DEFINITION OF A GALE

A gale is considered as any occasion when the mean wind speed over 10 consecutive minutes on the trace reached a value of 39 m.p.h. or more. Any such occasion between midnight and midnight constituted a day with gale, and a single day might count as a day with gale from 2 or more directions. Whenever a lull occurred of less than 60 minutes duration, the gale was considered as one entity, but after more than sixty minutes' lull an increase to gale force again was regarded as a new gale.

5.1 FREQUENCY OF DAYS WITH GALE

Table 3 gives the average, maximum and minimum number of gale days in each month and in the year. July, which has only one gale throughout the whole period, has the lowest average, but the four summer months, May, June, July and August, all average less than 1 gale per year.

	Average	Maximum	Minimum	% Occasions with gale in month
January	6.5	11	1	100
February	8.4	16	2	100
March	5.3	12	0	93
April	2.9	7	0	73
May	0.5	2	0	40
June	0.4	1	0	40
July	0.1	1	0	7
August	0.7	3	0	40
September	0.9	3	0	47
October	1.7	6	0	73
November	4.1	12	0	87
December	5.3	12	1	100
YEAR	36.7	50	20	

TABLE 3. Number of Gale Days per Month

The winter season, November to March, has 4 or more gales per month in each of the 5 months with a maximum of 8 in February. Each of these five months has had 11 or more gales on one occasion, and the months December, January and February have not passed without at least one gale in each.

On the average, there are 37 gale days per year, ranging from a minimum of 20 in 1946 to a maximum of 50 in 1944.

5.2 FREQUENCY OF DAYS WITH GALES FROM THE EIGHT CARDINAL DIRECTIONS

Table 4 gives the average and Table 5 the maximum number of days with gales from each direction in each month and the year.

	N	NE	E	SE	S	SW	W	NW
January	0.7	0.1	0.1	0.4	1.4	0.9	2.0	3.8
February	0.5	—	—	0.4	1.6	1.0	3.5	4.4
March	0.9	0.1	0.1	0.3	0.9	0.7	2.0	2.0
April	0.5	0.2	0.1	0.3	0.3	0.4	0.7	1.4
May	0.1	—	0.1	—	0.2	—	0.1	0.1
June	—	—	—	0.1	0.3	—	—	0.1
July	—	—	—	—	0.1	—	—	—
August	0.1	—	0.1	0.4	0.3	0.1	—	0.1
September	0.2	0.1	0.3	—	0.3	0.1	0.1	—
October	0.5	0.2	0.1	0.4	0.3	0.1	0.3	0.5
November	0.6	0.3	0.5	0.3	0.7	0.1	0.7	1.1
December	0.7	0.1	—	0.3	0.8	0.5	1.9	2.7
YEAR	4.7	1.0	1.3	2.8	7.1	3.8	11.2	16.1

TABLE 4. Average Number of Days with Gales from each Direction.

	N	NE	E	SE	S	SW	W	NW
January	3	1	2	2	4	2	5	7
February	1	–	–	2	5	3	12	9
March	3	1	2	2	3	2	8	7
April	2	2	1	1	2	2	3	4
May	1	–	1	–	1	–	1	1
June	–	–	–	1	1	–	–	1
July	–	–	–	–	1	–	–	–
August	1	–	2	2	2	1	–	1
September	2	1	2	–	2	1	1	–
October	2	2	1	4	2	1	2	4
November	4	4	3	2	5	1	3	7
December	2	1	–	1	3	2	5	7
YEAR	10	4	4	7	12	8	18	26

TABLE 5. Maximum Number of Days with Gales from each Direction.

It is apparent that gales from West and North-west are the most common at all seasons except summer, with an average of 27 per year and North-east to East least frequent with less than 3 per year. There is a subsidiary maximum from the South with 7 gales per year. The proportion of southerly gales is greatest in the summer when the total number is small and the majority of gales occur with tropical storms moving northward between Bermuda and the American coast.

February has had no gales from East or North-east but averages considerably more from South to North-west than any other month.

No table is given of the minimum number of days recorded with gale in each month as the figure is zero for every month in each direction except January and February which have not passed without at least one North-west gale in each. There has not been a year without at least 1 North, 3 South, 5 West and 12 North-west gales.

6.1. TOTAL DURATION OF GALES PER MONTH AND YEAR

Table 6 gives the total number of hours of gale in each month and the year, without regard to direction. February, with an average of more than 63 hours of gale, has much the highest figure, followed by January with 41. From this January-February maximum, values fall away in the two adjacent months, March and December, to less than half the February values, and in April and November to less than one-quarter of February.

	Average	Maximum	Minimum
January	40.7	113.1	3 5
February	63.1	128.3	5.2
March	25.5	56.0	—
April	11.5	42.8	—
May	0.6	4.3	—
June	1.5	11.5	—
July	0.5	8.0	—
August	6.2	41.7	—
September	5.0	25.1	—
October	8.2	25.5	—
November	14.1	62.1	—
December	26.8	74.7	2.0
YEAR	209.9	345.1	80.1

TABLE 6. Total Duration of Gales per Month in Hours

July, with one-half hour per month, has the shortest duration, but May has very little more, and June only 1½ hours. August and September have from 5 to 6 hours, which are mainly due to Tropical Depressions.

February 1947, with a total of 128.3 hours, or more than 4½ hours gale per day, is the windiest month in these records, and 1933 with a total of 345 hours, the windiest year.

Many months have passed without gales, and 1946 with 80 hours is the year with the shortest total duration.

6.2 TOTAL DURATION PER MONTH OF GALES FROM EIGHT CARDINAL DIRECTIONS

	N	NE	E	SE	S	SW	W	NW
January	1.8	.04	0.2	0.6	3.8	1.7	9.8	22.8
February	1.5	—	—	1.2	4.7	3.2	20.7	31.8
March	3.8	0.1	0.6	1.5	3.3	0.6	8.3	7.3
April	0.9	0.9	0.8	0.4	0.7	0.6	3.2	4.1
May	0.3	—	.05	—	0.2	—	.01	.02
June	—	—	—	.02	0.7	—	—	0.8
July	—	—	—	—	0.5	—	—	—
August	0.4	—	1.1	2.9	1.5	0.3	—	.01
September	1.7	.03	2.0	—	1.1	0.1	.01	—
October	1.4	1.2	.15	1.5	0.7	.08	1.7	1.4
November	1.5	0.9	2.4	0.7	2.2	.05	2.0	4.4
December	1.9	.04	—	1.0	1.5	0.9	7.8	13.6
YEAR	15.2	3.2	7.3	9.8	20.9	7.5	53.5	86.2

TABLE 7. Average total Duration in Hours per month and year of Gales from each Direction.

	N	NE	E	SE	S	SW	W	NW
January	14.8	0.7	2.8	6.9	12.6	7.3	24.3	81.7
February	5.0	—	—	8.8	18.0	12.7	109.2	74.4
March	17.5	1.5	8.7	16.5	14.0	3.5	35.0	18.4
April	5.0	12.7	12.5	2.5	6.7	4.0	30.5	35.7
May	4.3	—	0.7	—	2.4	—	0.2	0.3
June	—	—	—	0.3	8.7	—	—	11.5
July	—	—	—	—	8.0	—	—	—
August	6.7	—	16.0	25.7	10.3	4.7	—	0.2
September	24.7	0.5	19.5	—	9.0	1.7	0.2	—
October	11.5	12.5	2.3	12.0	3.7	1.2	12.5	10.0
November	8.0	13.1	30.0	5.1	21.3	0.7	9.0	46.7
December	11.0	0.7	—	7.2	7.7	6.7	40.0	37.1
YEAR	49.9	13.1	30.0	38.7	37.7	13.5	138.0	184.9

TABLE 8. Maximum total Duration in Hours per month and year of Gales from each Direction

Tables 7 and 8 give respectively the average and the maximum total duration of gales from each of the eight cardinal directions. It is seen that North-west gales with an average of 86 hours per year blow 60% longer than the westerly, with 53 hours, more than four times as long as any other direction, and account for almost half the total gale duration in a year. North-easterly gales have the shortest duration, lasting for slightly more than three hours per year.

6.3. DURATION OF INDIVIDUAL GALES FROM EACH CARDINAL DIRECTION

In addition to the total duration of gales in any period, it is of interest to know how long the average gale blows, and Table 9 gives the average duration of individual gales from each direction and Table 10 the maximum duration observed from each of these directions. It must be remembered in considering the average values that the number of cases is very small for the summer months, and also for certain directions, particularly North-east, East and South-east, so one gale of long duration may give the average an unduly high value.

	N	NE	E	SE	S	SW	W	NW
January	2.0	0.7	2.8	1.4	2.7	2.1	5.3	6.1
February	2.5	—	—	4.4	2.9	3.2	5.8	7.7
March	3.8	1.5	8.7	4.5	3.5	1.0	3.1	3.1
April	2.2	3.3	12.5	1.2	2.6	1.2	4.4	2.6
May	4.3	—	0.7	—	1.2	—	0.2	0.3
June	—	—	—	0.3	1.6	—	—	11.5
July	—	—	—	—	8.0	—	—	—
August	3.3	—	16.0	10.7	7.6	2.5	—	0.2
September	12.6	0.5	6.0	—	4.2	1.0	0.2	—
October	3.6	9.1	2.3	4.6	2.5	1.2	4.3	2.0
November	2.3	2.3	4.5	1.8	2.6	0.7	2.7	3.3
December	2.4	0.2	—	3.7	1.6	2.0	4.1	5.5
YEAR	3.0	2.7	5.7	3.7	2.8	2.0	4.5	5.2

TABLE 9. Average Duration in Hours of Individual Gales from each Direction in each Month and the Year

	N	NE	E	SE	S	SW	W	NW
January	8.7	0.7	2.8	5.3	9.3	7.3	17.4	70.1
February	5.0	—	—	8.8	8.9	10.5	24.7	52.3
March	13.3	1.5	8.7	16.5	14.0	3.0	28.0	18.3
April	5.0	6.3	12.5	2.5	6.7	4.0	28.5	16.0
May	4.3	—	0.7	—	2.3	—	0.2	0.3
June	—	—	—	0.3	4.0	—	—	11.5
July	—	—	—	—	8.0	—	—	—
August	6.0	—	16.0	25.7	10.3	4.7	—	0.2
September	24.7	0.5	19.5	—	9.0	1.7	0.2	—
October	11.5	12.5	2.3	12.0	3.3	1.2	12.5	8.0
November	8.0	5.3	29.3	4.7	13.7	0.7	9.0	26.5
December	11.0	0.3	—	7.2	6.0	3.7	30.5	23.7
YEAR	24.7	12.5	29.3	25.7	14.0	10.5	30.5	70.1

TABLE 10. Maximum Duration in Hours of Individual Gales from each Direction in each Month and the Year.

During the three winter months, as shown in Table 7, West and North-west account for 80% of the time gales blow. Westerly gales average over 4 hours in December, 5¼ hours in January and 5¾ hours in February, while North-westerly blows for approximately 5½, 6 and 7½ hours respectively in these same months. At this same season, Southerly, which are the next most common, average about 2½ hours each.

Although Easterly are relatively infrequent at all times, when they do occur they tend to blow for about 4 hours. South-west gales show the smallest average duration, and, also, the lowest maximum over the 14 years.

Table 10 shows that gales have blown from each direction for 10 hours or more, and, except for North-east, South and South-west for 24 hours with a maximum of over 70 hours from North-west on 28th, 29th, 30th and 31st January, 1933.

6.4. DURATION OF INDIVIDUAL GALES REGARDLESS OF DIRECTION

In exposed situations the actual direction of a gale is relatively unimportant, and it is of interest, therefore, to have data referring to continuous gales even when the direction changes. This is given in Table 11, the figures referring to periods where there was no lull for more than 1 hour. The total number of cases in each month are given as an indication of the relative reliability of the averages.

	Total Number of Gales 1932-47	Average Duration	Maximum duration
January	113	5.4	81.5
February	136	7.0	52.3
March	111	3.4	48.3
April	52	3.3	28.5
May	7	1.3	4.3
June	9	2.6	11.5
July	1	8.0	8.0
August	8	11.7	41.7
September	15	5.0	24.7
October	27	4.5	17.3
November	68	3.1	33.0
December	89	4.5	30.5
YEAR	636	4.9	81.5

TABLE 11. Duration in hours of individual Continuous Gales from any Direction with no break greater than 60 minutes.

May, with 1.3 hours per gale, has the shortest gales of any month, and August, with 11.7 hours, the longest, but each of these months experiences a gale only once in two years.

As shown in Section 12, gales in May are mainly caused by the few fronts which push south to Bermuda at this season. Such depressions as form on these fronts are usually of slight depth near Bermuda and consequently, on the rare occasions when they do give winds of gale force, the gale is of short duration.

Well developed tropical depressions, on the other hand, often move slowly, and, consequently, when one is close enough to cause a gale, the gale is likely to be of some duration. Such fully developed tropical storms, however, seldom affect Bermuda in May, but the number increases through the summer and hence the average duration of gales increases also to reach a maximum in August. The average duration decreases then until November, which has very few tropical depressions, and is a month in which frontal storms are not yet generally severe. In the next three months there is a steady increase in duration up to the February maximum of nearly seven hours caused by the frequent extensive storms of this month. There is a rapid improvement of conditions in March and April as fronts become less intense followed by the drop to the minimum values in May.

May, June and July, which have not had 12 hours of continuous gale, are very different from the remaining months which, except for October, have all had over 24 hours continuous gale with the maximum of 81.5 hours in January. The occasion of this maximum was the same as the North-west maximum in section 8, and the period of 6 days from 26th to 31st January, 1933, constitutes the week with longest duration of gales on record. A South-west gale beginning on 26th January, 1933, blew for 2½ hours and was followed after an interval of 1½ hours by 15½ hours of westerly gale lasting into the 27th when direction changed to North-west and blew for 11¼ hours. After an interval of 9 hours during which the speed gradually fell to 20 m.p.h., then rose to gale force again, the long period of 81.5 hours began with 2.7 hours Southwest, followed by 8.75 West and 70.1 North-west. The North-west gale continued until 31st when, after further intervals of 4 and 1¾ hours Northwest and North gales blew for another 0.8 hours. In the six days from 26th to 31st, therefore, there were 111½ hours of gale, or over 18½ hours per day.

7.1. MAXIMUM STEADY SPEEDS REACHED IN GALES

	N	NE	E	SE	S	SW	W	NW	All Directions
January	43	42	51	45	42	45	49	45	45
February	45	—	—	50	46	46	47	48	47
March	46	40	55	42	44	42	44	44	44
April	43	43	45	48	45	51	46	46	46
May	43	—	45	—	45	—	41	39	43
June	—	—	—	41	46	—	—	46	45
July	—	—	—	—	45	—	—	—	45
August	46	—	58	53	52	43	—	41	50
September	50	40	43	—	47	44	39	—	45
October	50	47	54	51	51	42	46	49	49
November	47	44	42	43	44	44	44	43	44
December	44	41	—	45	44	43	45	46	45
YEAR	45	43	45	47	45	45	46	46	46

TABLE 12. Average Maximum steady speed, m.p.h., reached in Gales from each Direction

Easterly gales in March have the highest value of 55 m.p.h., while westerly in September and North-westly in May just reach the class of gales. August, with 50 m.p.h., and May with 43 m.p.h., have, respectively, the highest and lowest average maxima. There is, therefore, relatively little variation in the average maximum, and it appears that the majority of gales do not exceed the minimum gale speed by more than 6 to 8 m.p.h.

Gales over 50 m.p.h. have been recorded from every direction, and over 60 m.p.h. from each direction except North-east and East.

	N	NE	E	SE	S	SW	W	NW	All Directions
January	52	42	51	50	50	58	64	65	65
February	52	—	—	62.	68	55	62	58	68
March	78	40	55	45	51	46	56	55	78
April	48	52	45	62	50	90	56	80	90
May	43	—	45	—	49	—	41	39	49
June	—	—	—	41	55	—	—	46	55
July	—	—	—	—	45	—	—	—	45
August	50	—	58	65	60	45	—	41	65
September	52	40	47	—	55	47	39	—	55
October	72	48	54	58	56	42	52	100	100
November	66	52	50	50	54	44	52	52	66
December	56	42	—	56	55	48	55	65	65
YEAR	78	52	58	65	68	90	64	100	100

TABLE 13. Absolute Maximum steady speed, m.p.h., reached in Gales from each Direction

With the exception of May and July, speeds of 55 m.p.h. have been recorded in all months, and 65 m.p.h. in every month except May, June, July and September. The maximum of 100 m.p.h. occurred from North-west in the October 1939 hurricane. The 90 m.p.h. given for April from South-west is low, as this was the maximum steady speed the anemometer could record at the time.

7.2. MAXIMUM GUST SPEED

Table 14 gives the average maximum gust in gales, and Table 15 the absolute maxima recorded.

	N	NE	E	SE	S	SW	W	NW	All Directions
January	57	59	74	58	57	65	66	59	61
February	56	—	—	69	63	68	63	64	64
March	59	55	78	54	60	62	60	57	59
April	59	65	69	63	62	73	62	59	62
May	55	—	61	—	61	—	56	49	58
June	—	—	—	55	64	—	—	57	62
July	—	—	—	—	64	—	—	—	64
August	58	—	81	71	71	63	—	48	67
September	64	59	59	—	65	60	50	—	61
October	69	70	71	69	69	72	62	64	66
November	60	66	57	59	57	59	58	55	58
December	57	58	—	59	60	64	61	59	60
YEAR	59	63	62	62	61	66	62	60	61

TABLE 14. Average Maximum Gust Speed, m.p.h., in Gales from each Direction

Easterly gales in August show the highest average of 81 m.p.h., and in 3 other months easterly exceeded 70 m.p.h. In August East, South-east and South each average maxima over 70 while, in October, values near 70 are reached in all directions except West and North-west. In every month the average, including all directions, is close to 60 m.p.h.

	N	NE	E	SE	S	SW	W	NW	All Directions
January	70	59	74	67	70	91	90	96	96
February	65	—	—	89	92	83	95	86	95
March	99	55	78	64	72	67	81	74	99
April	61	80	69	83	70	132	83	105	132
May	55	—	61	—	65	—	56	49	65
June	—	—	—	55	76	—	—	57	76
July	—	—	—	—	64	—	—	—	64
August	64	—	81	89	80	72	—	48	89
September	66	59	70	—	78	66	50	—	78
October	95	73	71	78	78	72	72	131	131
November	90	81	79	69	71	59	68	66	90
December	80	63	—	72	77	71	77	86	86
YEAR	99	81	81	89	92	132	95	131	132

TABLE 15. Absolute Maximum Gust Speed m.p.h. in Gales from each Direction

From Table 15 it is seen that gusts of over 80 m.p.h. have occurred from each direction, and over 60 m.p.h. in each month. The absolute maximum of 132 m.p.h. from the South-west was recorded with the hurricane of 1933, and, as stated earlier, this is not the true maxima, but the maximum the instrument would record.

The average maximum gust, taking all cases, is one-third greater than the average maximum steady wind.

8. SYNOPTIC CAUSES OF GALES

The vast majority of gales occur in winter, and are associated with fronts which have moved south and east from the U.S. Coast, and, in many cases, have developed deep depressions. Fronts from the west move across Bermuda at all seasons of the year, but are rare in the summer, and depressions which form then are seldom of any intensity in the Bermuda area.

Gales in the summer and early autumn are due chiefly to tropical depressions which have formed to the South and moved North past Bermuda.

Table 16 gives the percentage of gale days in the period under review on which the gale was due to a Tropical Disturbance.

During the four months December to March, all gales were due to frontal phenomena and associated depressions. The one Tropical Disturbance shown in April was felt in Bermuda in 1933 on the twenty-sixth of the month, and was estimated to be of 60 miles diameter only, with winds of hurricane speed over about half this distance. It was encountered by ships, but not by any other land station, and some opinions were expressed that it was more in the nature of a large Tornado than a Tropical Depression. Tropical storms affecting wider areas appeared in May to give one gale out of the seven recorded, and the proportion was doubled in June. July had only one gale, and that was due to a Tropical Depression, while in August and September, four out of every five gales were due to Tropical Depressions.

A – 6.4
S – 12

In October there is a great increase in frontal activity, and although the number of Tropical Depressions remains high, the proportion of gales due to Tropical Depressions falls to two out of every five gales. This proportion falls to one out of every eight in November, and no gales due to Tropical Depressions were recorded in December.

O – 10.8
N – 8.5

	Total Days with Gale	Total days with gale due to Tropical Depressions	Percentage due to Tropical Depressions
January	97	0	0
February	126	0	0
March	80	0	0
April	43	1	2
May	7	1	14
June	6	2	33
July	1	1	100
August	11	8	73
September	14	12	86
October	25	10	40
November	62	8	13
December	79	0	0
YEAR	551	43	8

TABLE 16. Percentage of Days when Gales due to Tropical Depressions.

9. SEQUENCE OF GALES

In the case of frontal gales, the synoptic conditions may vary considerably, but there is a general pattern of a depression passing, usually in a North-easterly direction, to the west of Bermuda with first a warm and then a cold front or succession of cold fronts passing through Bermuda. The wind will be South-east to South before the warm front between South and West in the warm sector, and West to North after the cold front. Gales from East to North-east occur when the centre forms in a more southerly latitude and passes to the south of Bermuda.

Unless the centre of the depression is near Bermuda, the pressure gradient in the warm sector is usually less than that before the warm front or behind the cold. It is quite common to have a very definite lull with the West to South-west winds after the warm front passes, freshening again before the cold front. This results in the figures shown in Table 17, which gives the percentage frequency with which a gale from one quarter is preceded or followed by a gale from another within one or six hours.

Direction of Gale	Preceded by other gale within		Followed by other gale within	
	1 Hour	6 Hours	1 hour	6 hours
NE to E	0	4	14	36
SE to S	2	4	8	24
SW to W	6	21	23	42
NW to N	17	32	1	4

TABLE 17. Percentage frequency of occasions when a Gale from one Quarter is preceded or followed by a Gale from another Quarter.

In almost all cases where a gale changes direction, the change is a veer, although cases of backing are not unknown.

It is seen that in almost no cases are gales from North-east, East, South-east or South preceded by another gale, nor are North-west or North gales followed by a gale from another direction.

The most noticeable connection is between South-west to West and North-west to North.

South-west to Westerly gales are followed by North-west to Northerly within six hours on two occasions out of five, and within one hour on one occasion out of four. However, only one North-west to Northerly gale in three is actually preceded by another gale within six hours, and for the hour interval the ratio is only one in six.

The connection between South-east to South and South-west to West is reflected by one South-east to South in four or five being followed, and the same proportion of South-west to West preceded, by another gale within six hours.

10. HIGH WINDS

Consideration of the occasions of high winds shows that tropical depressions are not at all as exclusive a cause of damage as is often suggested. In the period under review winds of hurricane speed 75 m.p.h., were caused by tropical storms on two occasions, and by frontal storms on one. Winds of 64 m.p.h. occurred on 10 days, of which only three occasions were due to Tropical Depressions, and of the 57 days with force 10, 55 m.p.h., only eight were due to Tropical Depressions.

It is apparent, therefore, that the severe frontal storms of winter give the majority of the high winds, and certainly cause, in total, more inconvenience and disruption of activity than the much rarer tropical storms.

Some of the data given has been available from the routine tabulations of this office, but most has been extracted specially, and I am indebted to Mr. R. H. Divall for assistance in this regard.

Meteorological Station
Bermuda
November 6th. 1947