HONG KONG OBSERVATORY

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Probability of Occurrence of Gales in the Harbour Area of Hong Kong during the Passage of Tropical Cyclones

by

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摘要

本報告以統計方法對熱帶氣旋引致香港港內出現烈風的概率作出研究。研究結果以概率等值線的圖表方式將颱風及強烈熱帶風暴引致出現烈風的情況顯示出來。各種影響港內出現烈風的因素也會在本報告作出討論。

Abstract

A statistical study was conducted to investigate the probability of occurrence of gales in the harbour area of Hong Kong during tropical cyclone scenarios. The results were depicted in the form of diagrams of probability isopleths of occurrence of gales for typhoons and severe tropical storms. Various factors that might affect the onset of gales in the harbour area were also discussed in this report.

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1. INTRODUCTION

One important consideration in issuing local tropical cyclone warnings in Hong Kong [Lam, 2000 and HKO, 2001] is the probability of occurrence of strong/gale/hurricane force winds in Hong Kong in relation to the forecast track of the tropical cyclone. A statistical forecasting tool has been in use for many years. In this tool, the reference location for wind strength is Waglan Island, about 19 km southeast of the Hong Kong Observatory Headquarters. Since there is significant regional variation of wind speed in Hong Kong, it would be useful to have a tool that makes reference to the wind condition in the urban area on both sides of the harbour area of Hong Kong.

This report describes the data and the procedures used to prepare diagrams of isopleths of the probability of the occurrence of gales in the harbour area of Hong Kong during the passage of tropical cyclones. It discusses various factors affecting the occurrence of gales in the harbour. The details of data preparation are given in Sections 2. The analysis procedures and the resulting isopleth diagrams are presented in Section 3. Factors affecting the onset of gales in the harbour are discussed in Section 4. Major findings of the study and some rules of thumbs when using the diagrams of isopleths are given in Section 5.

2. DATA

2.1 Anemometer Stations

As the harbour area of Hong Kong is sheltered by the hills both to the north and south, the chance of it having gales is much lower than the exposed Waglan Island. In order to have a large enough sample size and to minimize the bias due to local obstruction at a single anemometer station, all eight stations around the harbour were used in this study. The harbour area of Hong Kong adopted in this study [Lands Department, 1999] and the locations of Waglan Island (WGL) and the eight anemometer stations are shown in Figure 1. The eight stations are Hong Kong Observatory Headquarters (HKO), King's Park (KP), Kai Tak SE (KTSE), Star Ferry Tsim Sha Tsui (SFTST), Star Ferry Central (SFCEN), North Point (NP), Hong Kong International Terminal (HIT) and Mobil Depot (MBL).

2.2 Data Sets

All tropical cyclone cases from 1968-2001 with Strong Wind Signal No. 3 [Lam, 2000 and HKO, 2001] or higher signals were used in this study. Data checking for each tropical cyclone started and ended according to the times of issuance and cancellation of the corresponding Signal No. 3 respectively. Because wind data of automatic weather station (AWS) were not available for the entire period, the data set was a combination of running 10-minute mean wind speeds of the eight stations and on-the-hour 10-minute mean wind speeds of HKO, KTSE, and SFTST. Table 1 summarizes the data availability at these eight stations.

The track and intensity of the tropical cyclones used in this study are based on the best track analysis of the Hong Kong Observatory.

3. ANALYSIS

3.1 Onset and Cessation of Gales

The onset and cessation of gales in the harbour are taken as the first and the last occurrence of gales (10-minute mean wind) at any of the eight stations. Based on Chin et al. (1978), 13.0 m/s was taken as the threshold for gales at KP and 17.5 m/s at other stations. The gale wind duration of a tropical cyclone is the duration of time, rounding to the nearest hour, between the onset and cessation of gales.

3.2 Cases Used in Deriving Probability of Occurrence of Gales

There were in total 143 tropical cyclones requiring the issuance of Signal No. 3 or higher signals during 1968 to 2001. Gales occurred in 38 of these cases. Of these 38 cases, there were 6 cases in autumn or winter where the tropical cyclones were so far away from Hong Kong that the occurrence of gales were judged to be attributed significantly to the effect of the northeast monsoon prevailing at the time (Table 2). Excluding these 6 cases, a total of 32 tropical cyclone cases causing gales in Hong Kong were used in computing the probability of occurrence of gales in Hong Kong.

Table 3 shows the percentage of tropical cyclones giving rise to gales at each of the eight stations. Amongst them, SFTST had the highest percentage, while SFCEN had the lowest.

3.3 Procedure for Calculating Probability of Occurrence of Gale

The following procedures were applied to the 32 tropical cyclones that caused gales in the harbour from 1968 to 2001:

(a) The number of all typhoons (X_{TY}), severe tropical storms (X_{STS}), and tropical storms (X_{TS}) passing each 1^o square within 15-25 ^oN, 106-123 ^oE for the years 1968 to 2001 were counted from their hourly positions linearly interpolated from the 6-hourly best track positions (Table 4).

(b) The gale wind durations (as defined in Section 3.1) of these tropical cyclones were computed (Table 5) and the corresponding numbers of each classification of tropical cyclones (i.e. Y_{TY} for typhoons, Y_{STS} for severe tropical storms and Y_{TS} for tropical storms) passing each 1^o square within 15-25 ^oN , 106-123 ^oE were counted based on 1-hour steps (Table 6).

(c) The probability of occurrence of gales for each 1^o square due to the passage of the three classifications of tropical cyclones was calculated as (Table 7) :

Y_{TY}/X_{TY} for typhoons
Y_{STS}/X_{STS} for severe tropical storms
Y_{TS}/X_{TS} for tropical storms

(d) The gale isopleths for tropical storms / severe tropical storms / typhoons were constructed manually using results in Tables 4, 6 and 7, as well as segments of tropical cyclone tracks during which gales occurred (Figure 2). Since the probability of encountering gales should increase with the tropical cyclone intensity [Frank and Gray, 1980], the isopleths were also subjectively smoothed with the following rules :

(i) the isopleths of the same probability for more intense tropical cyclones should envelop those for the weaker ones; and

(ii) the shape of the isopleths for different tropical cyclones categories should largely be similar.

It should be noted that the total number of tropical cyclones in a 1^{o} square may be smaller than the sum of the numbers for the four tropical cyclone categories within the square because of changes in intensity of some tropical cyclones within the square.

Figures 3 and 4 show the isopleth diagrams of the probability of occurrence of gales in the harbour for typhoons and severe tropical storms respectively. As the number of cases with gales caused by tropical storms is too small, only the probability diagrams for typhoons and severe tropical storms have been prepared.

4. FACTORS AFFECTING ONSET OF GALES IN THE HARBOUR

4.1 Terrain

Hills both to the north and south of the harbour influence the occurrence of gales in the harbour areas (Figure 1). In Figures 3 and 4, the axis of the maximum probability points towards the southwest, consistent with the orographic setting of the harbour which is more exposed to winds from the east. Tropical cyclones located southwest of Hong Kong generally cause unobstructed easterlies and hence higher chances of reaching gale force. The relative maximum is some 50 km south of Hong Kong, a distance from which Hong Kong is well within the gale wind radius of tropical cyclones. For a tropical cyclone approaches Hong Kong from the east or southeast, the probability value does not rise to any significant value until the tropical cyclone gets very close. This is because the onset of northerly gales is hindered by the hills to the north of the harbour.

4.2 Tropical Cyclone Intensity

Tables 4 and 6 show that the occurrences of gales over the harbour were mainly caused by typhoons and severe tropical storms, and that the chance of having gales due to tropical storms was very small. Amongst the 32 tropical cyclones, there were 19 typhoons, 11 severe tropical storms and 2 tropical storms.

4.3 Tropical Cyclone Size

To assess the effect of tropical cyclone size on the onset of gales in the harbour, the probabilities of occurrence of gales at the gale wind onset point of the 32 tropical cyclones were plotted against the corresponding tropical cyclone sizes for typhoons and severe tropical storms in Figures 5 and 6 respectively. The two tropical storm cases were grouped into the severe tropical storm category for simplicity. Here, the gale wind onset point is the tropical cyclone position at the time of onset of gales in the harbour. The nominal probability of occurrence at that position is read from the isopleths in Figure 3 (for typhoons) or Figure 4 (for severe tropical storms). The largest diameter of the outermost closed isobar of the tropical cyclone on the surface charts is taken to be the tropical cyclone size, with the following rules:

(a) if the gradient at the outermost closed isobar is too slack, the second outermost closed isobar is used; and

(b) for an asymmetric tropical cyclone, the diameter of the major axis would be used.

Figures 5 and 6 show that large tropical cyclones tend to trigger gales in the region of lower nominal probability in the isopleth diagrams and vice versa for small tropical cyclones. Furthermore, one can define threshold lines for typhoons and severe tropical storms (the red lines in Figures 5 and 6), below which gale winds seldom occur. However, as shown in Figure 5, Typhoon Elsie (1975), one of the most intense typhoons that affected Hong Kong in October, deviated from this trend significantly. In spite of its small size, Elsie managed to bring gales to the harbour when it cut into the 30 % isopleth, a value much lower than the corresponding probability values for other tropical cyclones with similar sizes. Examination of surface charts revealed that the northeast monsoon arrived at southern China just when Elsie approached the coast of Guangdong (Figure 8). The rendezvous of Elsie with the northeast monsoon explained the early onset of gales in the harbour.

4.4 Northeast Monsoon in October and November

As discussed in section 3.2, there were six tropical cyclones which are not used for the construction of the isopleths of probability due to the effect of northeast monsoon. Except for Typhoon Ira, the gale onset points of these tropical cyclones were outside the 10 % region (Table 8 and Figure 7). Typhoon Rita (1978) even had a gale wind onset point at a distance over 500 km from Hong Kong. Thus the presence of the northeast monsoon may cause the onset of gales well before the tropical cyclones reaching the 50% probability isopleth. The location of a tropical cyclone in relation to the isopleths at the onset of gales varies from case to case depending on the arrival time and strength of the northeast monsoon.

5. CONCLUSIONS

5.1 The isopleths of probability of occurrence of gales in the Hong Kong harbour area during the passage of typhoons and severe tropical storms were constructed based on 32 tropical cyclones that caused gales to Hong Kong harbour area from 1968 to 2001.

5.2 The occurrences of gales in the harbour area of Hong Kong were mainly caused by typhoons and severe tropical storms. The chance of tropical storms causing gales in the harbour was very small.

5.3 The isopleths of probability of occurrence of gales in the harbour are elongated towards the southwest with very tight gradient on the eastern and southeastern sides. This is due to the harbour being exposed to winds from the east and sheltered from winds from the north.

5.4. As rules of thumbs :

(a) Larger tropical cyclones could give rise to gales in the harbour when they crossed isopleths of smaller probability.

(b) The arrival or presence of northeast monsoon during the approach of a tropical cyclone could result in early onset of gales in the harbour.

6. REFERENCES

Chin, P.C. & Leong, H.C.	1978	Estimation of wind speeds near sea level during tropical cyclone conditions in Hong Kong. Hong Kong Observatory Technical Note No. 45.
Frank, W.M. & Gray, W.M.	1980	Radius and frequency of $15ms^{-1}$ (30kt) winds around tropical cyclones, Journal of Applied Meteorology, Vol. 19, p219-223.
Lands Department, HKSAR Government	1999	Map of Hong Kong Special Administrative Region, Series HM50CL Sheets 1 & 2.
Lam, C.Y.	2000	Tropical cyclone warning system in Hong Kong, Regional Technical Conference on Tropical Cyclones and Storm Surges, Chiang Mai, Thailand 13-17 November 2000.
HKO	2001	HKO Pamphlet - Hong Kong's Tropical Cyclone Warning Signals (see Appendix I)

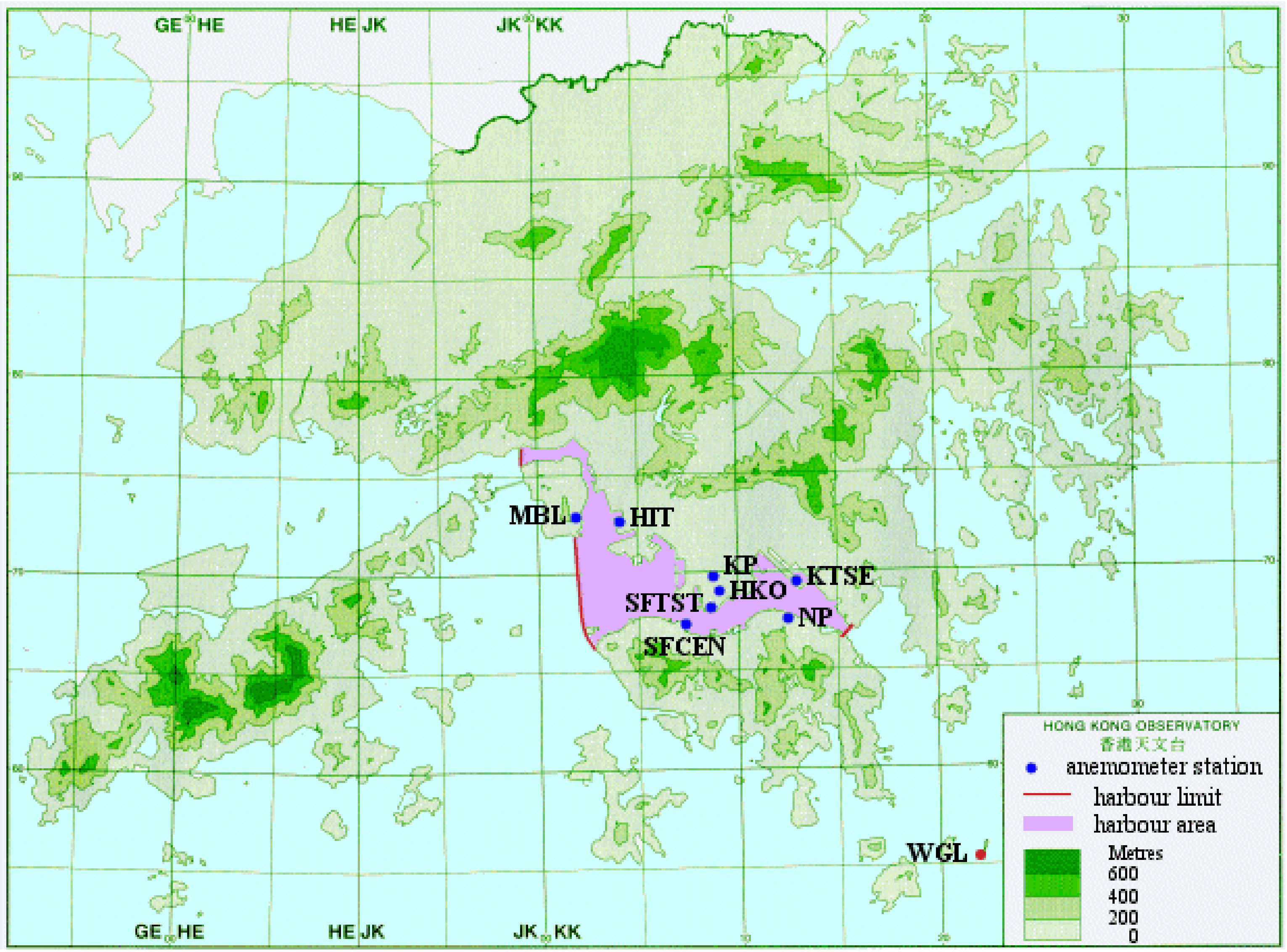


Figure 1 Limits of the harbour area of Hong Kong and locations of anemometer stations around the harbour and at Waglan Island.

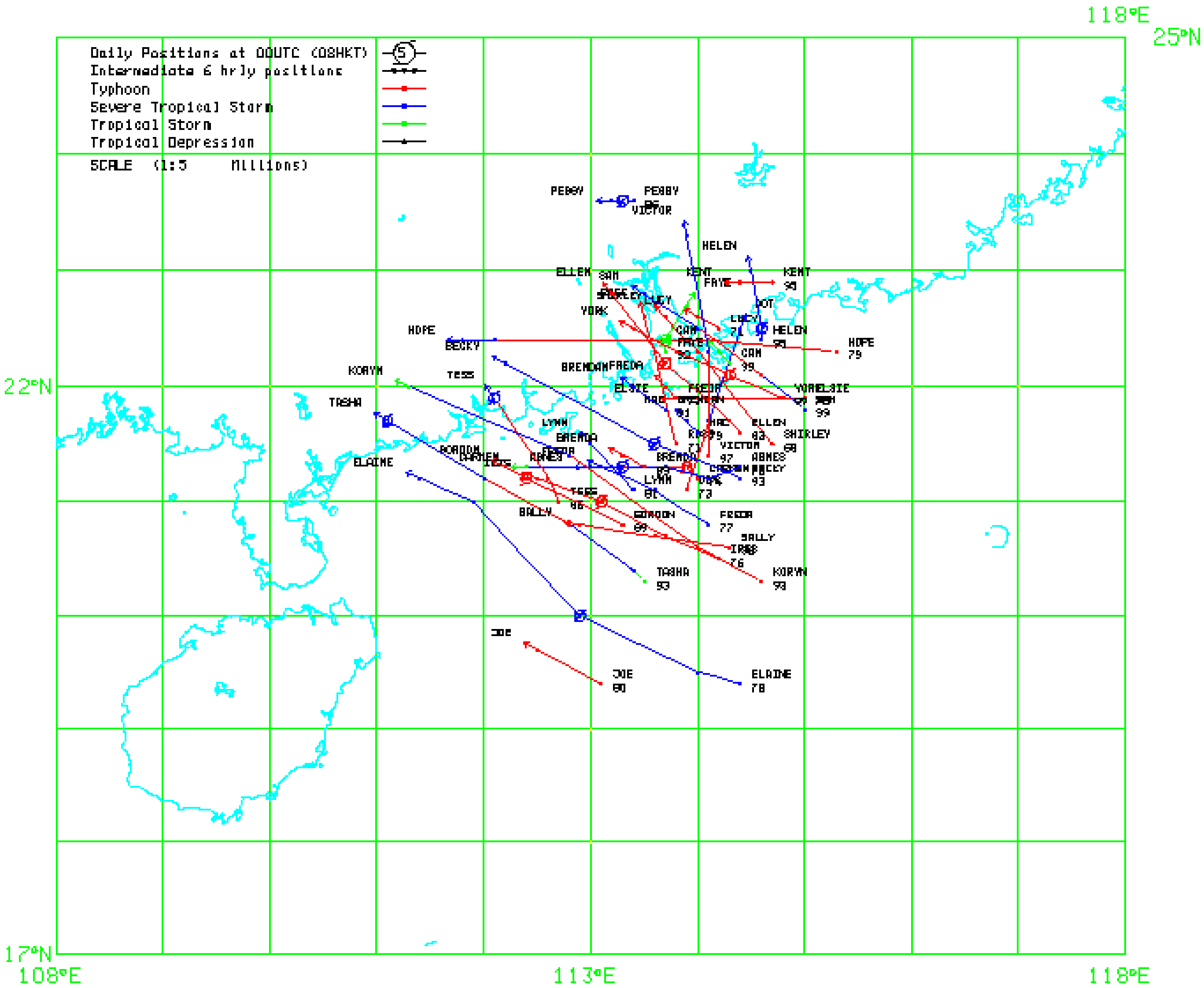


Figure 2 Segments of tropical cyclone tracks for which gales occurred in the harbour area of Hong Kong (1968-2001).

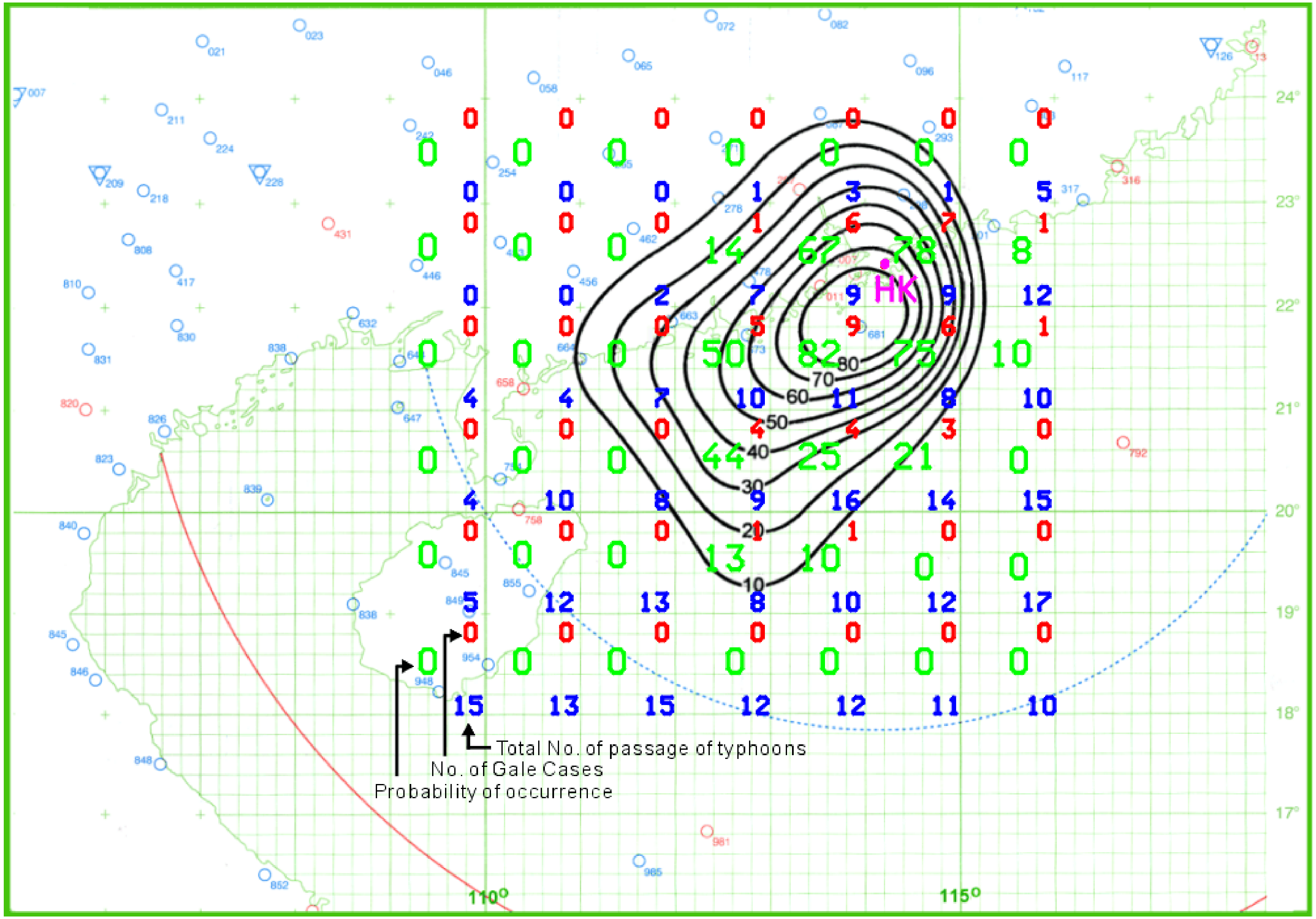


Figure 3 Probability of occurrence of gales in the harbour area of Hong Kong for typhoons.

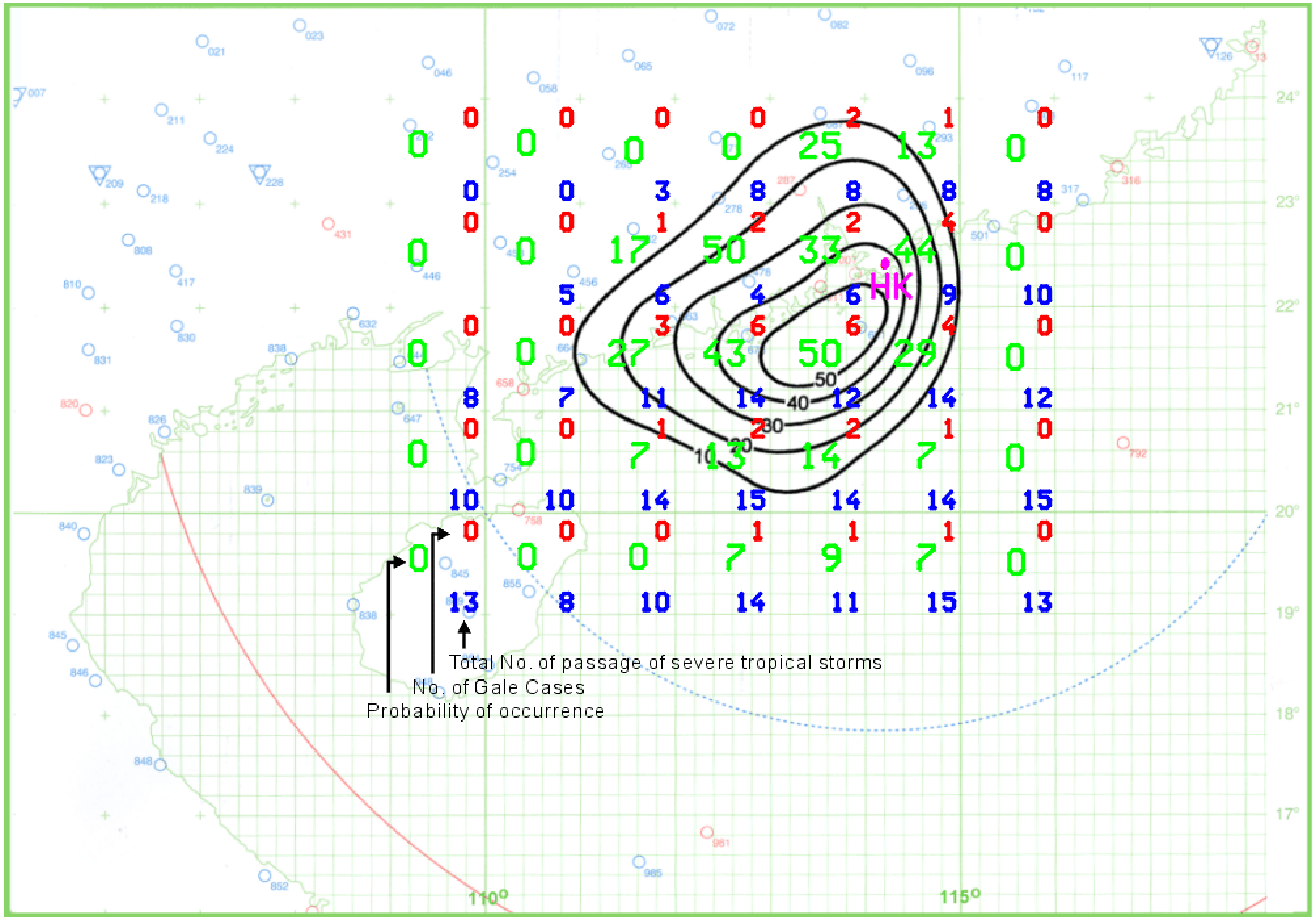


Figure 4 Probability of occurrence of gales in the harbour area of Hong Kong for severe tropical storms.

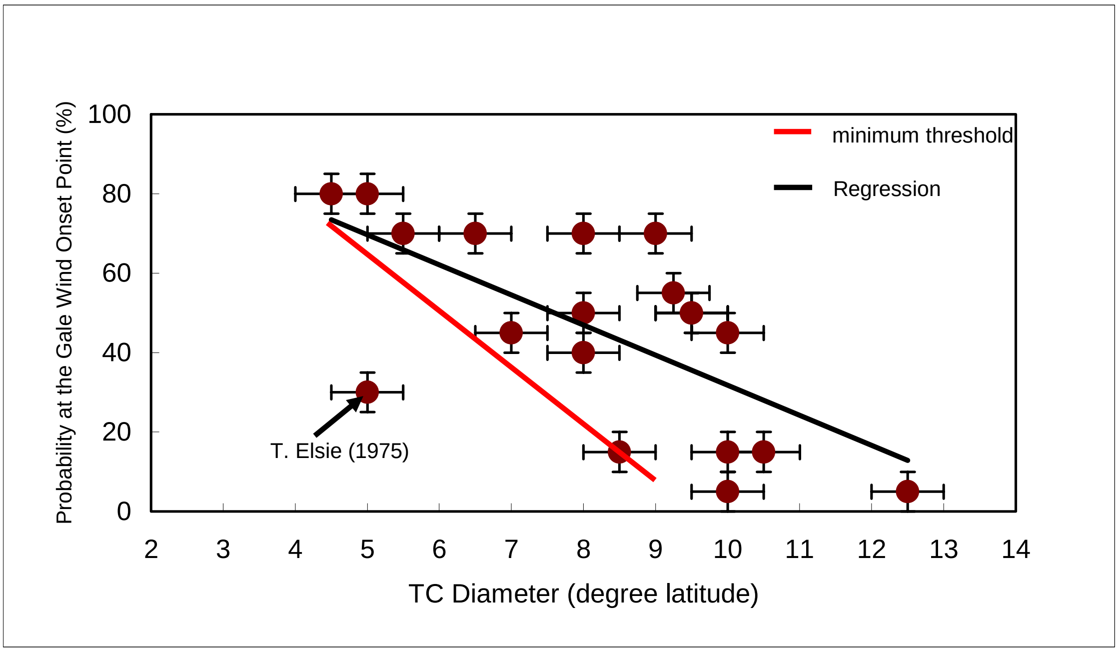


Figure 5 Nominal probability of occurrence of gales at the gale wind onset point against tropical cyclone (TC) diameter for typhoons. The combined effect of northeast monsoon and Typhoon Elsie (1975) resulted in an early onset of gales in the harbour.

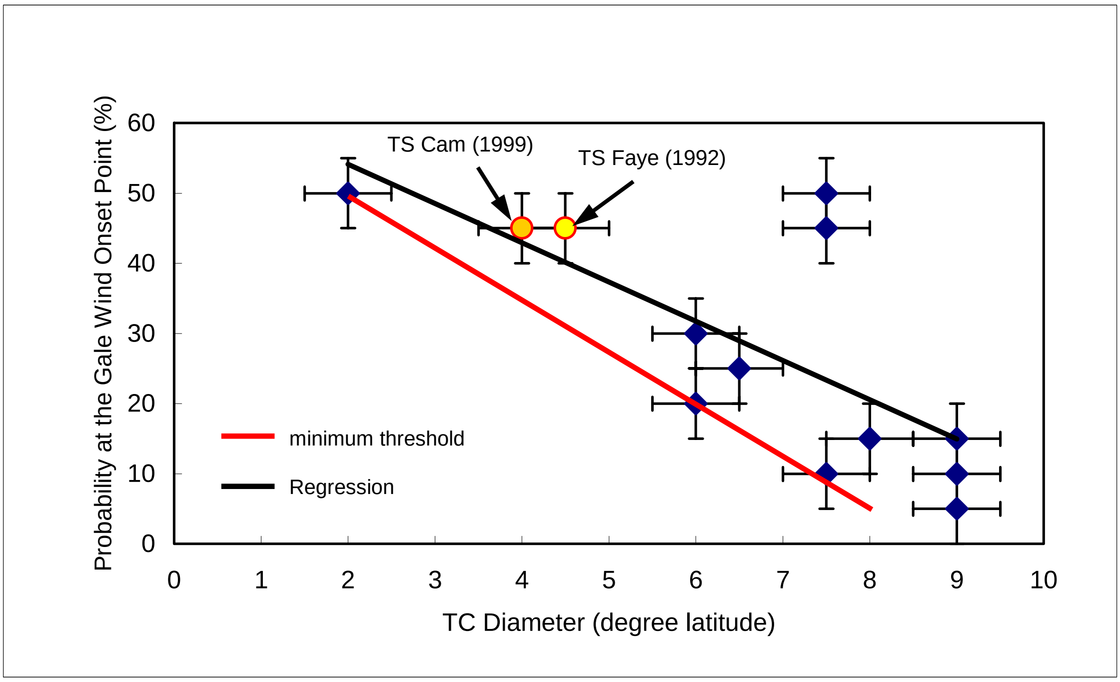


Figure 6 Nominal probability of occurrence of gales at the gale wind onset point against tropical cyclone (TC) diameter for severe tropical storms and tropical storms.

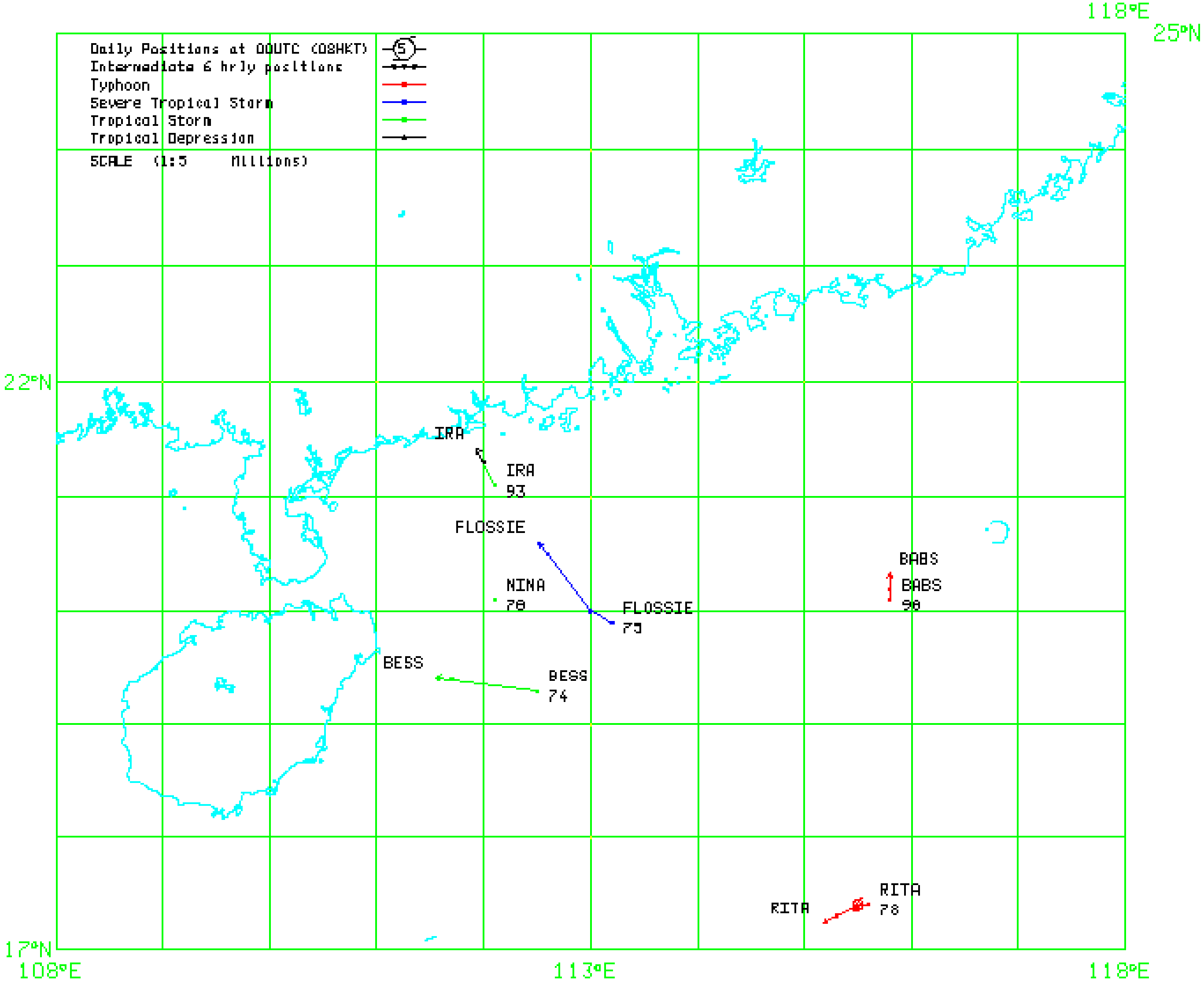


Figure 7 Segments of tracks of the six tropical cyclones which are excluded from the construction of isopleths of probability due to the effect of northeast monsoon (ref.: Section 4.4 and Table 8).

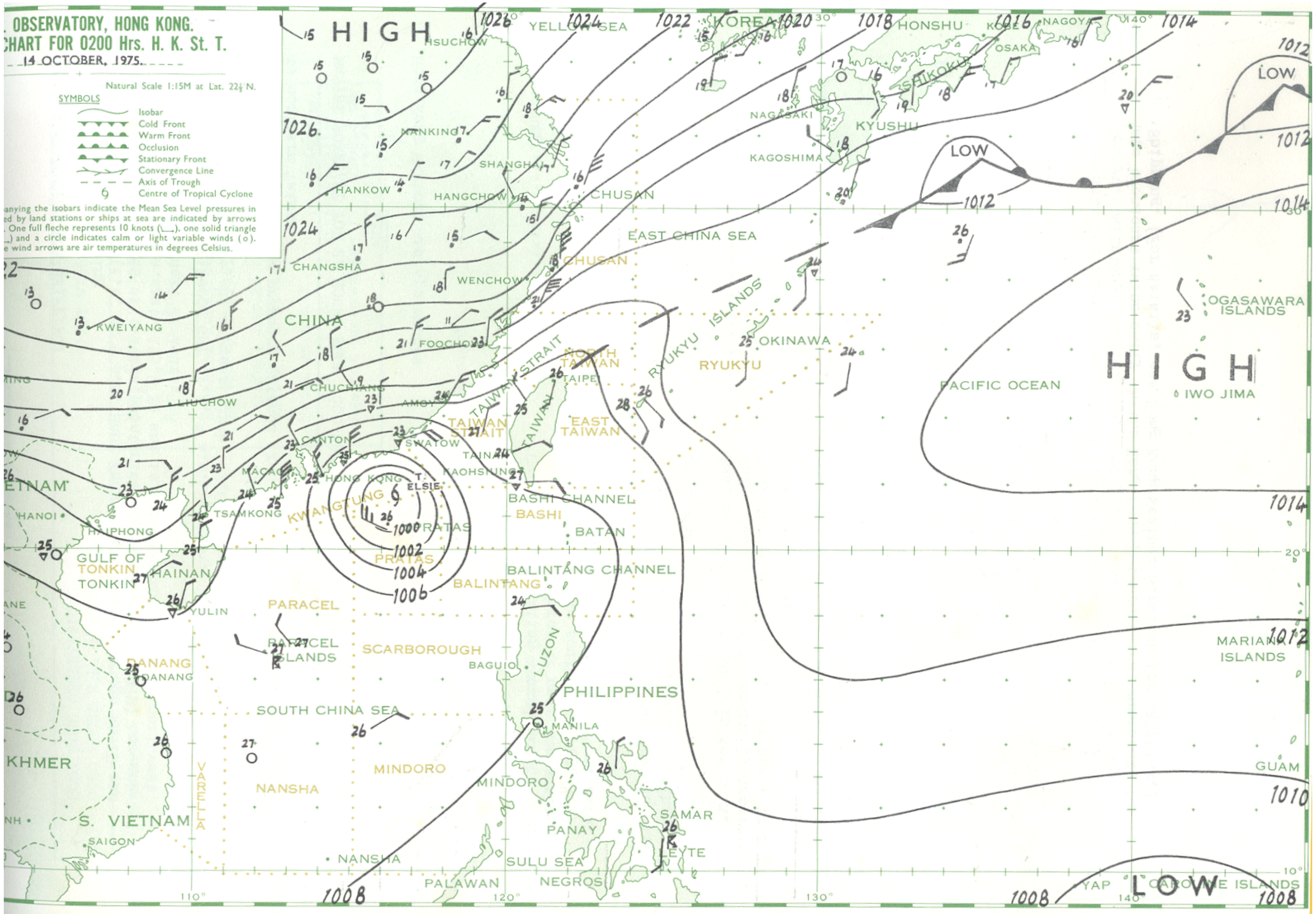


Figure 8 Weather map at 2:00 a.m. on 14 October 1975 showing the rendezvous of Typhoon Elsie and the northeast monsoon over southern China.

Table 1 Data availability (on-the-hour 10-minute mean wind and running 10-minute mean wind) for the eight anemometer stations around the harbour since 1968.

Station	On the hour 10-minute mean wind data available since	Running 10-minute mean data wind available since	Remark
HKO	1 Jan. 1968	9 Jul. 1984	-
KTSE	1 Jan. 1968	21 Oct. 1995	-
KP	12 Jun. 1992	12 Jun. 1992	-
SFTST	1 Jan. 1973	15 Dec. 1987	-
SFCEN	10 Apr. 1992	10 Apr. 1992	-
NP	16 Jan. 1996	16 Jan. 1996	-
HIT	16 May 1985	16 May 1985	-
MBL	1 Apr. 1987	1 Apr. 1987	MBL closed on 12 Aug. 1993

Table 2 Tropical Cyclones which are excluded from the construction of isopleths of probability due to the effect of northeast monsoon.

Tropical Cyclone Name	Period
T. Bess	11-14 Oct. 1974
STS Flossie	21-23 Oct. 1975
TS Nina	15-16 Oct. 1978
T. Rita	27-29 Oct. 1978
T. Ira	2-5 Nov. 1993
T. Babs	23-26 Oct. 1998

Table 3 Percentage of tropical cyclones giving rise to gales at the eight anemometer stations around harbour area of Hong Kong when Signal No. 8 was issued.

Station name	Total number of No. 8 Signal with gales	Total number of No. 8 Signal encountered	Percentage of occurrence of gales (%)
HKO	11	47	23.4
KP	6	17	35.3
KTSE	20	47	42.6
SFTST	24	40	60.0
SFCEN	1	17	5.9
NP	1	9	11.1
HIT	10	24	41.7
MBL	2	6	33.3

Table 4 Number of tropical cyclones in each 1^{o} square 1968-2001 (Apr-Dec)

																		Latitude
TS	0	0	1	1	1	0	1	2	7	4	6	6	11	7	7	4	7	24-25
	1	2	2	3	6	4	8	2	9	10	8	5	6	5	5	4	6	23-24
	3	5	5	10	10	5	10	4	9	9	9	6	7	7	3	5	9	22-23
	9	8	10	12	11	11	12	6	10	8	7	9	8	4	5	13	14	21-22
	9	8	9	7	8	11	10	12	10	10	10	11	11	6	11	15	11	20-21
	6	9	12	11	7	13	15	11	18	15	12	17	19	21	18	11	9	19-20
	9	7	12	11	7	13	16	9	15	11	12	19	19	18	13	12	7	18-19
	6	5	5	5	7	9	11	14	17	15	13	11	12	16	10	8	9	17-18
	6	9	8	7	7	10	14	9	3	11	14	6	9	13	5	2	1	16-17
	5	5	4	6	8	9	13	11	12	13	15	3	9	6	6	4	4	15-16
STS	0	0	0	0	0	0	1	2	5	2	5	7	4	4	5	9	6	24-25
	0	0	0	0	0	3	8	8	8	8	4	5	3	1	4	7	6	23-24
	0	1	2	1	5	6	4	6	9	10	8	8	3	2	5	7	5	22-23
	4	7	6	8	7	11	14	12	14	12	7	11	5	4	4	7	6	21-22
	5	8	8	10	10	14	15	14	14	15	13	12	5	3	4	7	6	20-21
	5	10	15	13	8	10	14	11	15	13	14	10	4	6	6	5	11	19-20
	6	7	10	8	8	14	14	9	12	11	18	11	7	8	6	7	8	18-19
	6	7	5	5	7	10	14	12	9	9	8	9	6	5	7	5	10	17-18
	0	4	5	6	3	6	10	6	6	6	8	11	10	9	10	6	8	16-17
	0	2	6	7	7	5	10	9	12	12	9	14	14	9	10	6	8	15-16
TY	0	0	0	0	0	0	0	0	0	0	1	5	10	9	15	19	18	24-25
	0	0	0	0	0	0	1	3	1	5	2	5	8	8	10	15	13	23-24
	0	0	0	0	0	2	7	9	9	12	10	9	11	10	10	18	15	22-23
	1	2	3	4	4	7	10	11	8	10	10	11	8	15	16	18	15	21-22
	3	3	2	4	10	8	9	16	14	15	8	13	15	18	12	16	15	20-21
	1	3	3	5	12	13	8	10	12	17	14	11	10	12	14	18	13	19-20
	5	8	12	15	13	15	12	12	11	10	11	11	14	13	14	18	20	18-19
	4	6	6	11	14	14	15	15	9	8	11	10	10	11	13	17	18	17-18
	0	3	4	6	9	12	14	16	15	12	10	7	5	7	12	13	15	16-17
	0	1	2	2	4	5	7	9	7	7	8	7	6	6	8	14	16	15-16
Longitude	106-107	107-108	108-109	109-110	110-111	111-112	112-113	113-114	114-115	115-116	116-117	117-118	118-119	119-120	120-121	121-122	122-123	

Table 5 Times of Onset and Cessation of gales in the harbour area of Hong Kong		
TC Name	Onset (UTC)	Cessation (UTC)
	yyyymmddhh	yyyymmddhh
SHIRLEY	1968082106	1968082114
FREDA	1971061717	1971061717
LUCY	1971072204	1971072205
ROSE	1971081612	1971081621
DOT	1973071613	1973071623
CARMEN	1974101823	1974101912
ELSIE	1975101401	1975101409
IRIS	1976091814	1976091905
FREDA	1977092410	1977092414
AGNES	1978072608	1978072704
ELAINE	1978082616	1978082708
HOPE	1979080203	1979080213
MAC	1979092305	1979092305
JOE	1980072202	1980072204
LYNN	1981070616	1981070620
ELLEN	1983090817	1983090906
TESS	1985090516	1985090600
PEGGY	1986071123	1986071201
BRENDA	1989052009	1989052010
GORDON	1989071719	1989071801
BRENDAN	1991072321	1991072323
FAYE	1992071723	1992071803
KORYN	1993062703	1993062718
TASHA	1993082005	1993082100
BECKY	1993091621	1993091705
HELEN	1995081123	1995081204
KENT	1995083108	1995083109
SALLY	1996090816	1996090820
VICTOR	1997080207	1997080217
SAM	1999082202	1999082216
YORK	1999091520	1999091611
CAM	1999092602	1999092603

Table 6 Number of occurrences of gales in the harbour area of Hong Kong for each 1^{o} square, 1968-2001 (Apr-Dec)

	106-107	107-108	108-109	109-110	110-111	111-112	112-113	113-114	114-115	115-116	116-117	117-118	118-119	119-120	120-121	121-122	122-123	Latitude
TS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-25
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23-24
	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	22-23
	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	21-22
	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	20-21
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19-20
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-19
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-18
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16-17
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15-16
STS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-25
	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	23-24
	0	0	0	0	0	1	2	2	4	0	0	0	0	0	0	0	0	22-23
	0	0	0	0	0	3	6	6	4	0	0	0	0	0	0	0	0	21-22
	0	0	0	0	0	1	2	2	1	0	0	0	0	0	0	0	0	20-21
	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	19-20
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-19
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-18
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16-17
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15-16
TY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-25
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23-24
	0	0	0	0	0	0	1	6	7	1	0	0	0	0	0	0	0	22-23
	0	0	0	0	0	0	5	9	6	1	0	0	0	0	0	0	0	21-22
	0	0	0	0	0	0	4	4	3	0	0	0	0	0	0	0	0	20-21
	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	19-20
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-19
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-18
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16-17
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15-16
Longitude	106-107	107-108	108-109	109-110	110-111	111-112	112-113	113-114	114-115	115-116	116-117	117-118	118-119	119-120	120-121	121-122	122-123	

Table 7 Probability of occurrence of gales in the harbour area of Hong Kong for each 1° square, 1968-2001 (Apr-Dec)

	106-107	107-108	108-109	109-110	110-111	111-112	112-113	113-114	114-115	115-116	116-117	117-118	118-119	119-120	120-121	121-122	122-123	Latitude
TS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-25
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23-24
	0	0	0	0	0	0	0	25	11.111	0	0	0	0	0	0	0	0	22-23
	0	0	0	0	0	9.0909	8.3333	0	0	0	0	0	0	0	0	0	0	21-22
	0	0	0	0	0	0	0	8.3333	0	0	0	0	0	0	0	0	0	20-21
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19-20
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-19
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-18
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16-17
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15-16
STS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-25
	0	0	0	0	0	0	0	25	12.5	0	0	0	0	0	0	0	0	23-24
	0	0	0	0	0	16.667	50	33.333	44.444	0	0	0	0	0	0	0	0	22-23
	0	0	0	0	0	27.273	42.857	50	28.571	0	0	0	0	0	0	0	0	21-22
	0	0	0	0	0	7.1429	13.333	14.286	7.1429	0	0	0	0	0	0	0	0	20-21
	0	0	0	0	0	0	7.1429	9.0909	6.6667	0	0	0	0	0	0	0	0	19-20
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-19
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-18
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16-17
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15-16
TY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-25
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23-24
	0	0	0	0	0	0	14.286	66.667	77.778	8.3333	0	0	0	0	0	0	0	22-23
	0	0	0	0	0	0	50	81.818	75	10	0	0	0	0	0	0	0	21-22
	0	0	0	0	0	0	44.444	25	21.429	0	0	0	0	0	0	0	0	20-21
	0	0	0	0	0	0	12.5	10	0	0	0	0	0	0	0	0	0	19-20
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-19
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-18
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16-17
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15-16
Longitude	106-107	107-108	108-109	109-110	110-111	111-112	112-113	113-114	114-115	115-116	116-117	117-118	118-119	119-120	120-121	121-122	122-123	

Table 8 Nominal probability of occurrence of gales at the point of gale onset for the six excluded tropical cyclones (ref.: Table 2)

Tropical Cyclone Name	Period	Probability of occurrence of gales at the gale wind onset point (%)	Remark
T. Bess	11-14 Oct. 1974	less than 10 %	SMS* to Signal No. 3
STS Flossie	21-23 Oct. 1975	less than 10 %	NE Monsoon
TS Nina	15-16 Oct. 1978	less than 10 %	SMS to Signal No. 3
T. Rita	27-29 Oct. 1978	less than 10 %	Signal No. 3 to SMS
T. Ira	2-5 Nov. 1993	about 20%	NE Monsoon
T. Babs	23-26 Oct. 1998	less than 10 %	NE Monsoon

*SMS stands for strong monsoon signal

Appendix I

香港天文台
Hong Kong Observatory

Meaning of signals

1 A tropical cyclone is centred within about 800 kilometres (km) of Hong Kong and may later affect Hong Kong.

3 Strong wind is expected or blowing in the Victoria harbour, with a sustained speed of 41-62 kilometres per hour (km/h), and gusts which may exceed 110 km/h.

8 Gale or storm force wind is expected or blowing in the Victoria harbour, with a sustained wind speed of 63-117 km/h from the quarter indicated and gusts which may exceed 180 km/h.

9 Gale or storm force wind is increasing or expected to increase significantly in strength.

10 Hurricane force wind is expected or blowing, with sustained speed reaching upwards from 118 km/h and with gusts that may exceed 220 km/h.

Important points to note

- The weather in different parts of Hong Kong cannot be simply inferred from the signal issued. Simply knowing what signal is issued is not enough. **You should** take note of the latest tropical cyclone information and related announcements broadcast on radio and TV, and given in the Observatory's Internet website (http://www.hko.gov.hk, http://www.weather.gov.hk, http://www.info.gov.hk/hko) to decide on the actions to take in response to the signal issued.
- Tropical Cyclone Warning Signals are to warn the public of the threat of **WINDS** associated with a tropical cyclone.
- Due to local topographical conditions, winds at your locality may be substantially different from those in the harbour areas. Winds are often stronger over offshore waters and on high ground. Winds are less strong in areas sheltered from the prevailing wind direction.
- The Hong Kong Observatory provides to the public detailed information on regional wind and rain through a diversity of channels, especially the Internet. Members of the public should consider their own circumstances and level of acceptable risk when taking precautions in response to warnings.
- When the Standby Signal No.1 is issued, you should take the existence of the tropical cyclone into account in planning your activities.
- When the No.3 signal is issued, secure all loose objects, particularly on balconies and roof tops. Secure hoardings, scaffoldings and temporary structures. Winds are normally expected to become generally strong in the harbour areas within 12 hours after this signal is issued. Winds over offshore waters and on high ground may reach gale force.
- When the No.8 signal is issued, complete all precautions before gales commence. Winds are normally expected to reach gale force in the harbour areas within 12 hours after a No.8 signal replaces a No.3 signal.
- When the No.9 or No.10 signal is issued, all precautions should be completed. Stay indoors and away from exposed windows and doors to avoid flying debris.

信號的意義

1 有一熱帶氣旋集結於香港約800公里之範圍內，稍後可能影響香港。

3 維多利亞港內吹強風或將有強風，持續風力每小時41至62公里，陣風更可能超過每小時110公里。

8 維多利亞港內風力已達或將達每小時63至117公里之烈風或暴風程度，由所指之方向吹襲，而陣風可能超過每小時180公里。

9 烈風或暴風風力現正或將會顯著增加。

10 風力已達或將達颶風程度，即持續風力每小時118公里或以上，而陣風可能超過每小時220公里。

注意事項

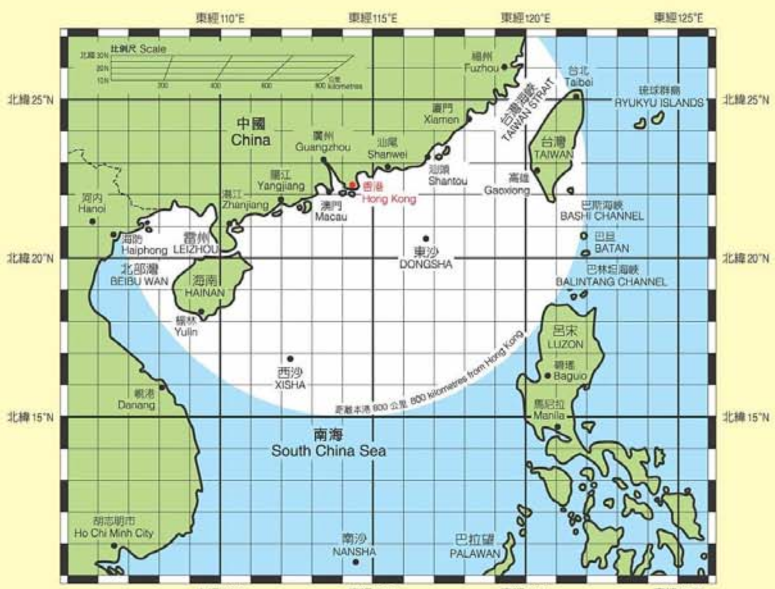
- 香港不同區域的天氣情況不能夠單由發出了甚麼信號而推斷得到。只知道發出了甚麼信號是不足夠的，**你應該**留意電台、電視台及天文台網頁所提供之有關熱帶氣旋最新消息及有關報告（網址為 http://www.hko.gov.hk, http://www.weather.gov.hk, http://www.info.gov.hk/hko），然後決定採取適當的相應行動。
- 發出熱帶氣旋警告信號是為了警告市民關於熱帶氣旋所帶來的**風力**威脅。
- 由於各區地形不同，你所在區域的風力與海港附近的風力可能有顯著差異。一般來說，離岸海域及高地風力較市區為強，由於風向關係而受地形掩蔽的地區風力較其他地區為弱。
- 天文台透過多種途徑，特別是互聯網，向公眾提供各區風力及雨量的詳細資料。市民應該因應自己的具體情況和可接受的風險水平，作出適當的預防措施。
- 1號戒備信號發出後，計劃一切活動時，都要考慮到熱帶氣旋之影響。
- 3號信號發出後，應將所有容易被風吹動之物件綁緊，放置於露台及屋頂之物件更要綁緊。圍板、棚架和臨時建築物，亦應鞏固。通常，發出了這個信號後12小時之內，海港一帶會普遍吹強風，在離岸海域及高地的風力更可能達烈風程度。
- 8號信號發出後，應在烈風吹襲前完成所有預防措施。通常，由8號信號取代3號信號後12小時之內，海港一帶風力會達烈風程度。
- 到了發出9號或10號信號時，應已做妥所有預防措施。這時，切勿外出並應遠離當風的門窗，以免被隨風吹來的碎片擊中。

香港天文台
Hong Kong Observatory

香港熱帶氣旋警告信號
Hong Kong's Tropical Cyclone Warning Signals

1	T	戒備 Standby
3	⊥	強風 Strong Wind
8 西北 NW	▲	**西北**烈風或暴風 **NW'**LY Gale or Storm
8 西南 SW	▼	**西南**烈風或暴風 **SW'**LY Gale or Storm
8 東北 NE	▲▲	**東北**烈風或暴風 **NE'**LY Gale or Storm
8 東南 SE	▼▼	**東南**烈風或暴風 **SE'**LY Gale or Storm
9	⧗	烈風或暴風風力增強 Increasing Gale or Storm
10	✚	颶風 Hurricane

熱帶氣旋途徑繪畫圖
Tropical Cyclone Plotting Map



熱帶氣旋按下表分類
Tropical cyclones are classified as follows

	中心附近之最高持續風速（公里/小時） Maximum sustained winds near the centre (km/h)
熱帶低氣壓 Tropical Depression	< 63
熱帶風暴 Tropical Storm	63-87
強烈熱帶風暴 Severe Tropical Storm	88-117
颱風 Typhoon	118 或以上 or more

在繪畫熱帶氣旋中心的移動途徑時，應留意偶然會出現偏離了一般動向的短期不規則性移動。出現這類偏差的原因部份由於確定熱帶氣旋中心位置的困難，而部份亦由於中心移動的方向及速度有短期性波動。
熱帶氣旋移動方向及距離香港的方位均以十六點方位表示，因此報告中的方位與實際方位可能相差達11¼度。例如，一颱風中心位於香港79至101度的任何方位，向259至281度任何方向移動，均可稱為“集結在香港以東…向西移動…。”這並非一定表示該颱風直趨香港，因其移動途徑與“直指香港”途徑之間可能相差達22度。

When plotting the track of the centre of a tropical cyclone, it is important to note that there can be short term erratic departures from the general direction of movement. These departures are partly due to difficulties in locating the centre of the tropical cyclone, and partly due to short term fluctuations in the direction and speed of movement of the centre.
The direction towards which a tropical cyclone is moving and the bearing of its centre from Hong Kong are each given to the nearest point of a 16-point compass bearing. Thus the actual bearing will be within 11¼° of the reported value. For example, the centre of a typhoon on any bearing between 79° and 101° and moving on any heading between 259° and 281° is said to be "centred......east of Hong Kong and moving west......" It will be seen that this statement does not necessarily mean that the centre is heading directly towards Hong Kong as its course could be as much as 22° off the direct "collision" course.