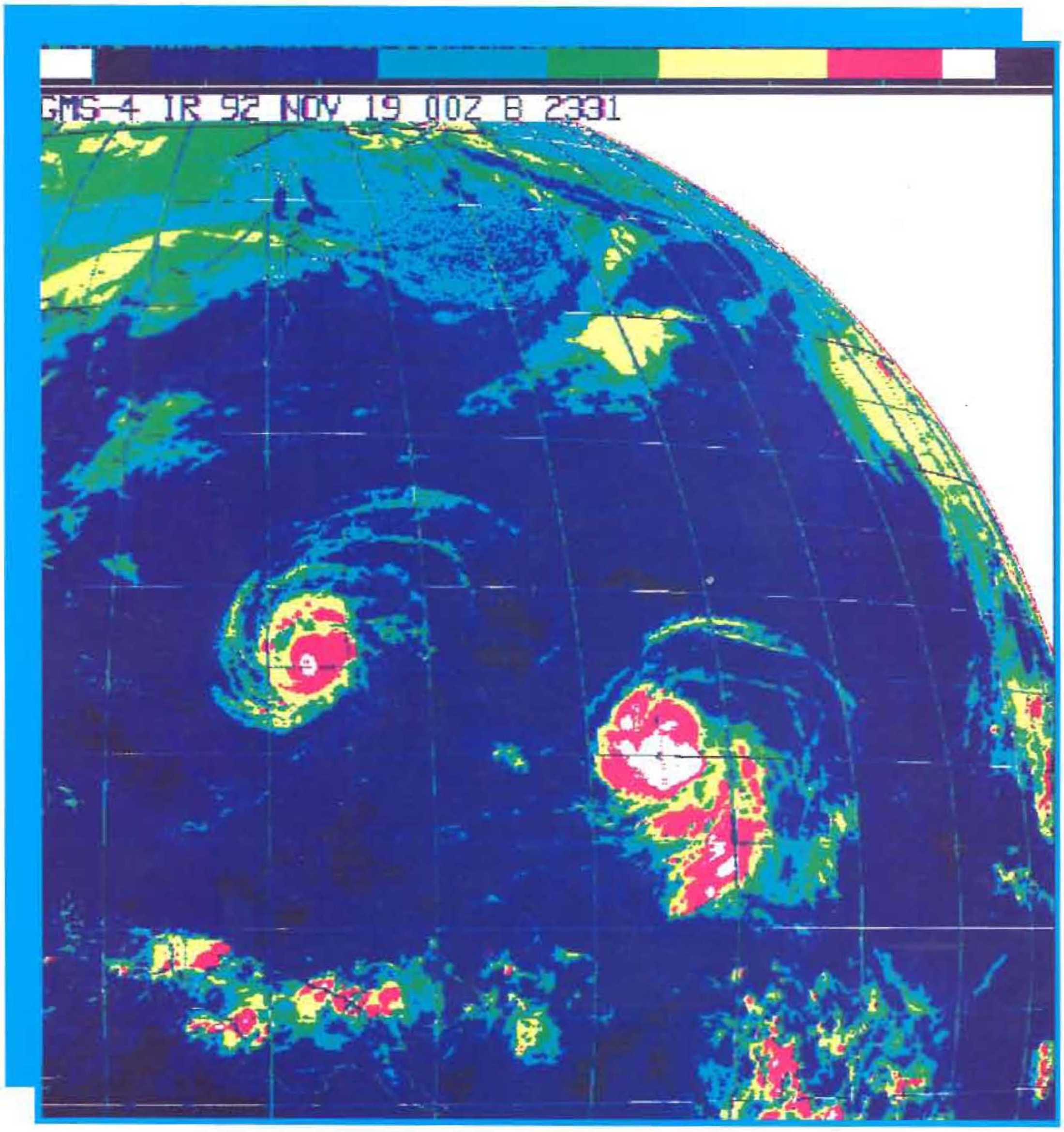
香港氣象學會

HKMetS BULLETIN, Volume 3, Number 1, 1993

HONG KONG METEOROLOGICAL SOCIETY

BULLETIN



About the cover

The cover picture shows a GMS4-IR image of Typhoons Hunt (9232) and Gay (9231) over the North Pacific Ocean at 0000Z on 19 November, 1992. The eyes of both storms can be clearly seen, Hunt near 15N 142E, Gay near 10N 165E. *(image courtesy of James Cook University).*

The Hong Kong Meteorological Society Bulletin is the official organ of the Society, devoted to editorials, articles, news, activities and announcements of the Society.

Members are encouraged to send any articles, media items or information for publication in the Bulletin.

For guidance see the "INFORMATION FOR CONTRIBUTORS" in the inside back cover.

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CONTENTS

Editorial

This issue of the *Bulletin* has, unfortunately, been somewhat delayed in its publication. In part this was due to the heavy editorial load to which the members of the Editorial Board were subject consequent upon the preparation of the Proceedings of the Second International Conference on East Asia and Western Pacific Meteorology and Climate. Despite the delay we hope that the contents of this issue of the *Bulletin* which contains some very interesting papers will be considered by you to have been worth the extra waiting time.

The first paper in this issue, by C.Y. Lam of the Royal Observatory Hong Kong, addresses in more detail the subject matter, *El Nino and Hong Kong Weather,* of a presentation which the author made at the 6th Hong Kong Meteorological Society Research Forum on *Short Term Climate Fluctuation* held at Hong Kong Baptist College on 12 December, 1992. In the paper Mr. Lam compares the wet springs of 1983 and 1992 in Hong Kong and seeks explanations in terms of ENSO and related regional circulation changes. He also proposes a rainfall producing mechanism which might help in further understanding of the conditions which led to such an excess of precipitation in those springs.

In the second paper Johnny C.L. Chan and Man-Him Ng of the City Polytechnic of Hong Kong stay on the subject of rainfall in Hong Kong but in this case they examine the well known phenomenon of summer morning showers. The paper investigates the physical processes thought responsible for these morning showers and attempts to produce a prediction algorithm suitable for operational purposes.

The third paper, a short note by W.L. Chang and K.H. Tam of the Royal Observatory Hong Kong, reports on the different types of tropical cyclone generated wave spectra recorded by the acoustic wave recorder sited on the sea bed off Waglan Island, to the south-east of Hong Kong.

The rest of the *Bulletin* continues the same general format of previous issues with the regular features *News and Announcements, Hong Kong Weather Reviews,* and *Meeting Reviews* included as before. In addition there is a new feature which it is hoped will be a yearly occurrence, the *1992 Tropical Cyclone Summary for the Western North Pacific Ocean (west of 180 degrees).* This gives summaries of all 1992 season tropical cyclones occurring in the western North Pacific Ocean and includes tracks for all storms affecting Hong Kong and towards the end of the season satellite imagery of some of the major storms.

The Editorial Board hope that you find this issue interesting and useful. Any and all feedback is welcome. Your support for future issues is still sought in the form of contributions of either papers or correspondence.

Bill Kyle, Editor-in-Chief

C.Y. Lam

Royal Observatory

Hong Kong

El Nino / Southern Oscillation and Spring Weather in Hong Kong

ABSTRACT

The rainfall in the spring of 1992 was the highest on record since observations at the Royal Observatory, Hong Kong, began in 1884. The ample rainfall was accompanied by above-normal relative humidity and cloud amount and below-normal temperature. In many ways, it was very similar to the spring of 1983. Both springs occurred during the mature phase of a warm El Nino / Southern Oscillation (ENSO) episode. Statistics showed that nearly all springs with extreme rainfall in Hong Kong were associated with ENSO and that on average the wetter ENSO springs tended to be cooler than drier ones. Observations showed that the rain was associated with a rain belt over southern China, where moist southwesterly winds of above-normal strength encountered frequent pulses of cool continental air from the north. Mean 850 hPa wind charts indicated that the southwesterly wind anomaly might be associated indirectly with the descending branch of an anomalous east-west Walker circulation which forms part of the ENSO phenomenon. It is however not clear what brought about the southward intrusions of cool air.

Introduction

1992 in Hong Kong will be long remembered for its wet and gloomy spring. Day after day rain fell and records were broken one after another. Overcast conditions lasted so long that the absence of sunshine became a subject of daily conversation at the time.

The freak weather attracted much attention from the press. They reported that the construction industry lost millions of dollars (*Sunday Standard*, 21 June, 1992). At the climax of the spell, vegetable production in the New Territories was reduced by half (*Wah Kiu Yat Po*, 12 April, 1992) while San Miguel Brewery experienced a significant decrease in beer sales (*Target*, 6 May, 1992). There were also reports of people suffering from depression over the persistent grey, rainy weather (*South China Morning Post*, 21 June, 1992).

Similar abnormal conditions were also experienced in Guangdong and nearby provinces. By April 1992, it was apparent that the gloomy and rainy weather had had considerable impact on the spring rice crop. Vegetable production was 30% less than normal. Floods and landslides caused great disruptions to land transport (*Wen Wei Po*, 8 April, 1992). There were also reports of hospitals full of patients with illnesses attributed to the persistent humid and rainy conditions (*Wen Wei Po*, 13 April, 1992).

This article will describe the meteorological aspects of the episode in Hong Kong. It will be compared with a very similar episode which occurred in spring 1983. The phenomenon will then be discussed in the regional context and its likely association with El Nino / Southern Oscillation (ENSO) will also be examined.

Spring 1983 and 1992

Climatologically, the mean temperature in Hong Kong falls to its minimum at the beginning of February (Peterson, 1963). The months of February - April mark the gradual recession of the influence of the northeast monsoon and may be conveniently called spring in Hong Kong.

The exceptionally wet spring in 1992 was followed by a record 4-month drought in August - November. The total rainfall in February - April 1992 was 877.4 mm, more than three times the normal (here taken to be the average for 1961-1990). It was the highest record for the quarter since records began in 1884. The previous record was set in 1983 when 840.1 mm of rainfall was reported. The ample rainfall in spring 1992 was accompanied by above-normal relative humidity and cloud amount and below-normal mean temperature. These parameters are plotted as deviations from monthly normals in Figure 1.

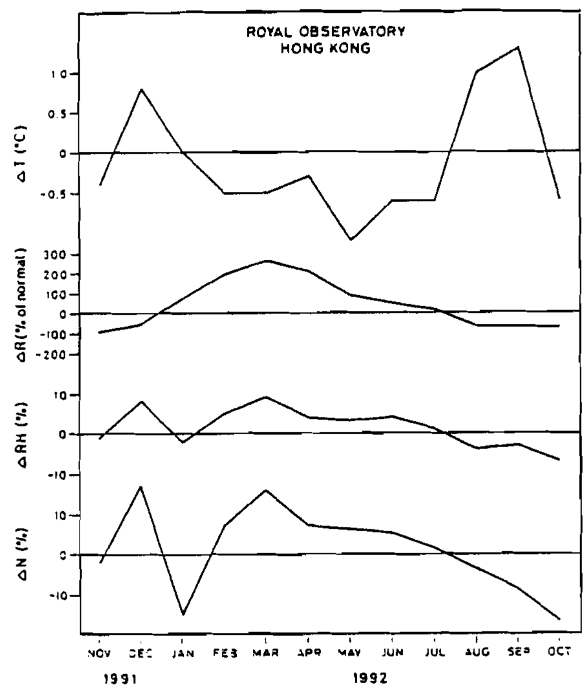

Figure 1 Deviations of monthly meteorological parameters from normal as observed at Royal Observatory headquarters, Hong Kong. ΔT: deviation of mean air temperature; ΔR: relative deviation of total rainfall; ΔRH: deviation of mean relative humidity; ΔN: deviation of mean cloud amount.

The onset of the anomalous conditions in February 1992 and their persistence into July, although less pronounced after April, are clearly depicted. The transition into drier than normal conditions later in the year is also shown.

Noting that 1983 was also a year with extreme rainfall in spring, the meteorological conditions of the months February - April in both 1983 and 1992 are tabulated together against normal values in Table 1. It is of great interest to note the similarities between the two springs *viz.* above-normal rainfall, RH and cloud amount and below-normal temperature and hours of bright sunshine. While 1992 had a wetter spring in terms of total rainfall, the spring of 1983 was gloomier with less hours of bright sunshine, especially in February and March. Figure 2 shows the variation of sunshine hours compared with normal and illustrates the persistence of the anomaly over a period of months.

Table 1 Meteorological conditions in the springs of 1983 and 1992 compared with normal. Data: Royal Observatory, HK.

Parameters	1983	1992	normal*
Rainfall (mm)			
February	241.0	142.8	48.0
March	428.0	242.4	66.9
April	171.1	492.2	161.5
Mean Temperature (°C)			
February	14.8	15.4	15.9
March	17.1	18.0	18.5
April	23.2	21.9	22.2
Mean Relative Humidity (percent)			
February	86	83	78
March	84	90	81
April	85	87	83
Mean Cloud Amount (percent)			
February	88	80	73
March	92	92	76
April	84	85	78
Bright Sunshine (hours)			
February	36.5	64.1	97.7
March	33.3	37.6	96.4
April	96.0	75.5	108.9

* 1961-1990 average

That the mean temperature during the two episodes was below normal might be taken as an indication that the winter monsoon in Hong Kong, as measured near the earth's surface, was stronger than normal. Figure 3 shows that the monthly prevailing winds at Waglan Island between February and April in 1983 and 1992 had northerly components stronger than normal.

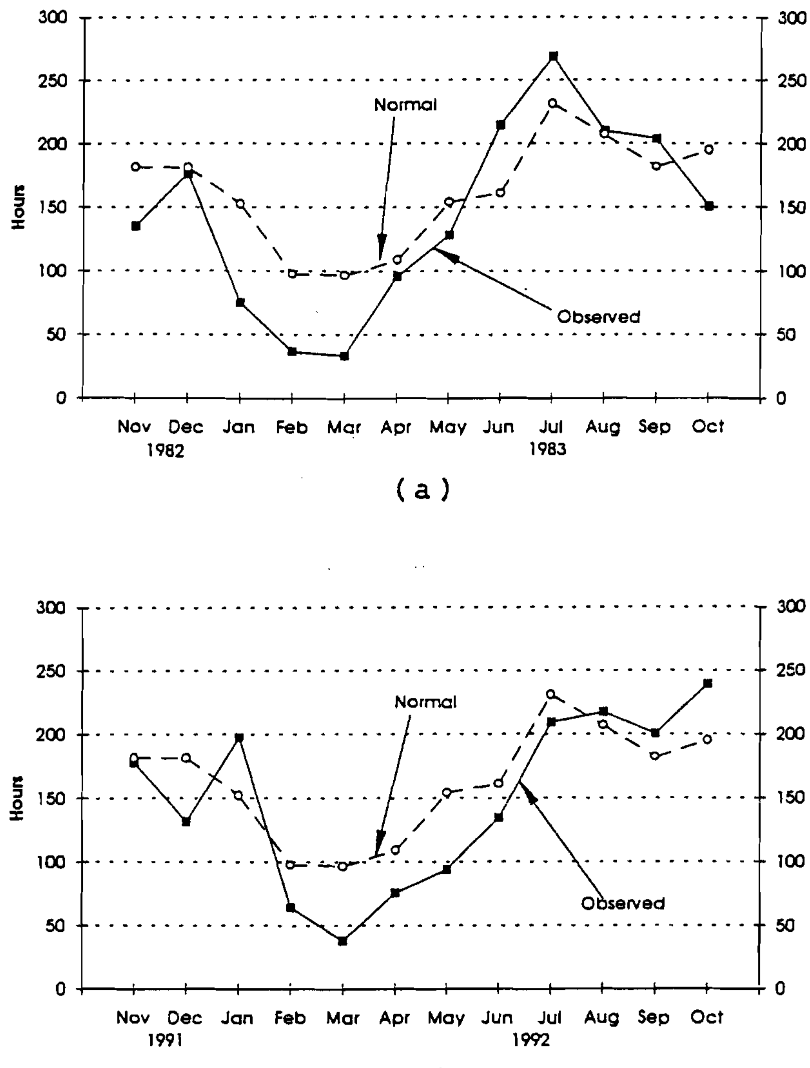

Figure 2 Duration of bright sunshine observed at King's Park, Hong Kong, compared with normal. (a) 1982-83 (b) 1991-92.

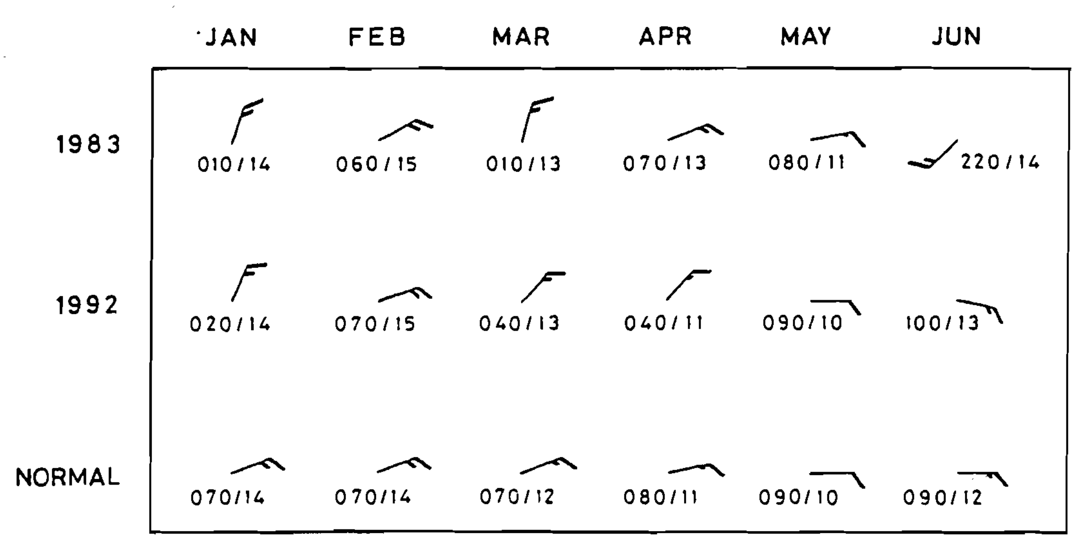

Figure 3 Monthly prevailing wind at Waglan Island, Hong Kong, compared with normal.

Usually one would expect a stronger winter monsoon to bring drier conditions to Hong Kong. That the opposite occurred during the two episodes rendered them very special.

Table 2 850 hPa conditions over Hong Kong.
Data: King's Park, Kowloon, Hong Kong

Parameters	1983	1992	average 1971-80
Scalar Mean Wind Speed (ms^{-1})*			
February	7.9	7.4	6.0
March	8.1	9.8	6.5
April	8.7	8.1	6.5
Vector Mean 00 UTC/12 UTC Wind Direction (degrees)			
February	219/230	222/234	217/217
March	223/232	213/218	209/208
April	210/227	221/227	204/216
Mean temperature (°C)			
February	8.9	6.9	6.0
March	9.8	10.9	9.0
April	11.3	10.7	11.3
Mean Relative Humidity (percent)			
February	86	83	76
March	83	83	79
April	75	73	77

* average of 00 UTC and 12 UTC observations

The answer lies, at least partly, in the upper-air conditions. Table 2 shows that during the two springs, the speed of southwesterlies at 850 hPa (about 1½ km above sea-level) was substantially higher than the 1971-80 average. The air at 850 hPa was also on the whole warmer and carried above-average amounts of water vapour. April in both years was a little drier than the average but the higher wind speed more than compensated for this and ensured that the water vapour flux at 850 hPa was higher than usual. One might see the cloudy and rainy conditions as a product of an enhanced vapour-laden airstream from the southwest in the lower atmosphere rising over a persistent cold airmass over Hong Kong.

Regional Perspective

The anomalous conditions which hit Hong Kong in spring 1992 were not confined to a single spot. To see the episode in the regional context, the spatial distributions of rainfall and temperature anomalies in Asia (and part of Australia) are portrayed in Figure 4 (*after* Long-range Forecast Division, Japan Meteorological Agency, 1992).

Regarding rainfall, in both February and April 1992, Hong Kong was embedded in a belt of stations with rainfall in the first quintile, that is, rain much heavier than normal, which extended across the northern part of the South China Sea and southern China, through Taiwan and the Ryukyus to Japan (Figure 4(a) and (c)). In contrast, central China was dry. In March, the westernmost part of the belt was broadened to cover central China but an area with below-normal rainfall could still be seen around Shandong and northeastern China (Figure 4(b)). Throughout the period, rainfall in Indonesia, the southern Philippines and Micronesia had rainfall in the lowest quintile. Northern Australia was in the same category at first but dry conditions were later confined to only the northeastern quadrant. It is interesting to point out here that drought around this time of the year in the above regions is a signature of ENSO events (Ropelewski *et al.*, 1987).

Concerning temperature, February 1992 saw a belt of below-normal temperature across southern China and extending towards the Ryukyu Islands, broadly coinciding with the belt of heavy rain noted above (Figure 4(d)). In March, below-normal temperature had a more extensive coverage over southern and central China (Figure 4(e)), again echoing the more widespread rain in the area in the same month. The area of cooler than normal conditions was more restricted in April, being confined to southwestern China in Figure 4(f). Table 1 did show that the mean temperature in Hong Kong was below normal in that month; it was not apparent in Figure 4(f) probably as a result of spatial resolution and the analysis procedure involved.

At higher latitudes, conditions much warmer than normal were recorded in Siberia in February 1992, which persisted into March albeit with less significant magnitude. A similar anomaly was also observed during the 1982-83 winter, at the peak of the strongest ENSO event ever measured (Quiroz, 1983). In April, a belt of positive temperature anomaly was found over northern China around 40°N.

Synoptic observations during spring 1992 showed frequent waves in the mid-tropospheric westerlies, crossing China from west to east and bringing with them excursions of cold air from the north to southern China. Perhaps this might

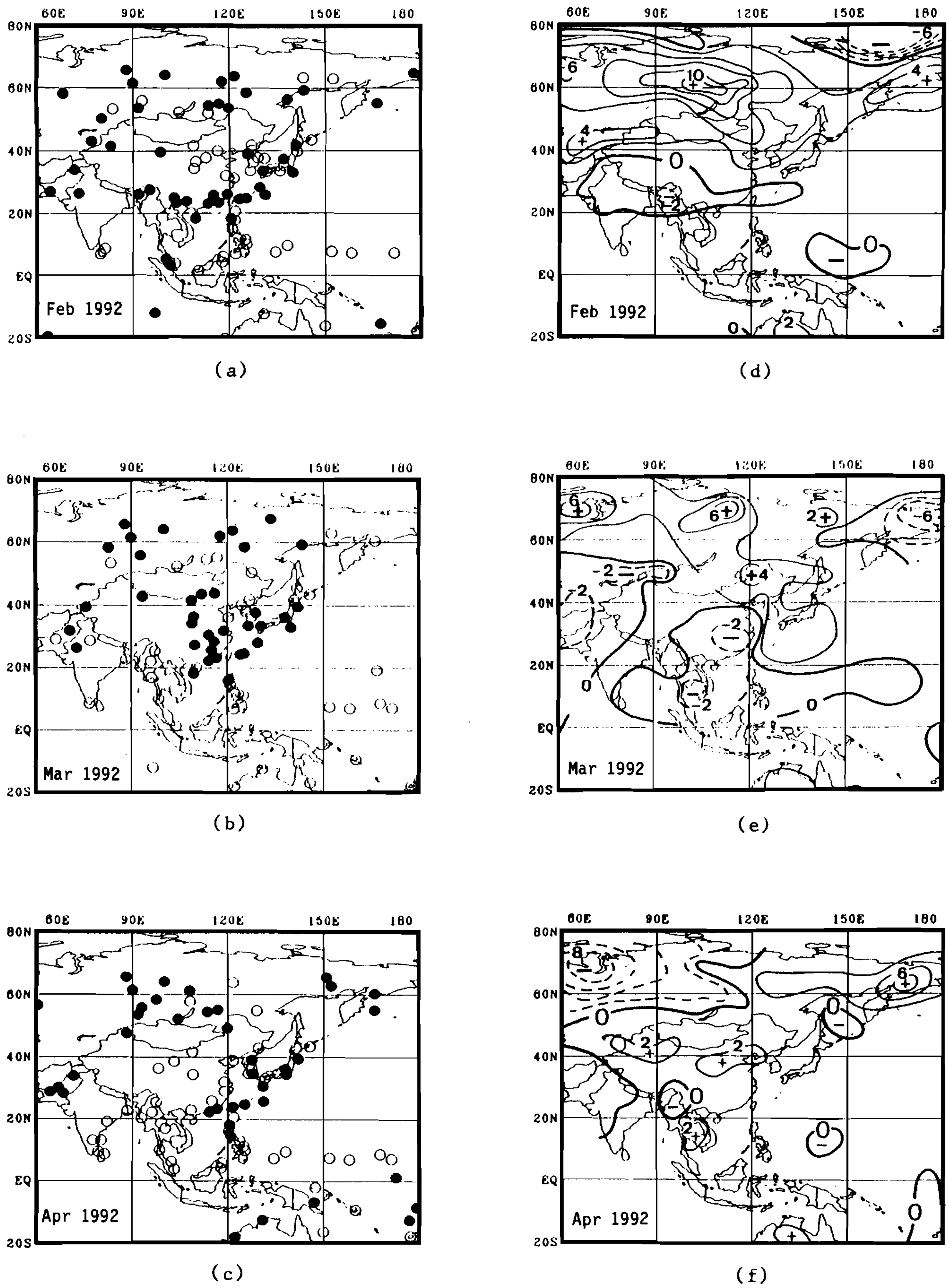

Figure 4 Deviation of rainfall and temperature in spring 1992 from normal. (a) - (c): Stations with rainfall in highest quintile (•) and lowest quintile (o) in the indicated month. (d) - (f): Temperature anomalies in the indicated month, negative anomaly contours dashed. (adapted from Long-range Forecast Division, Japan, 1992.)

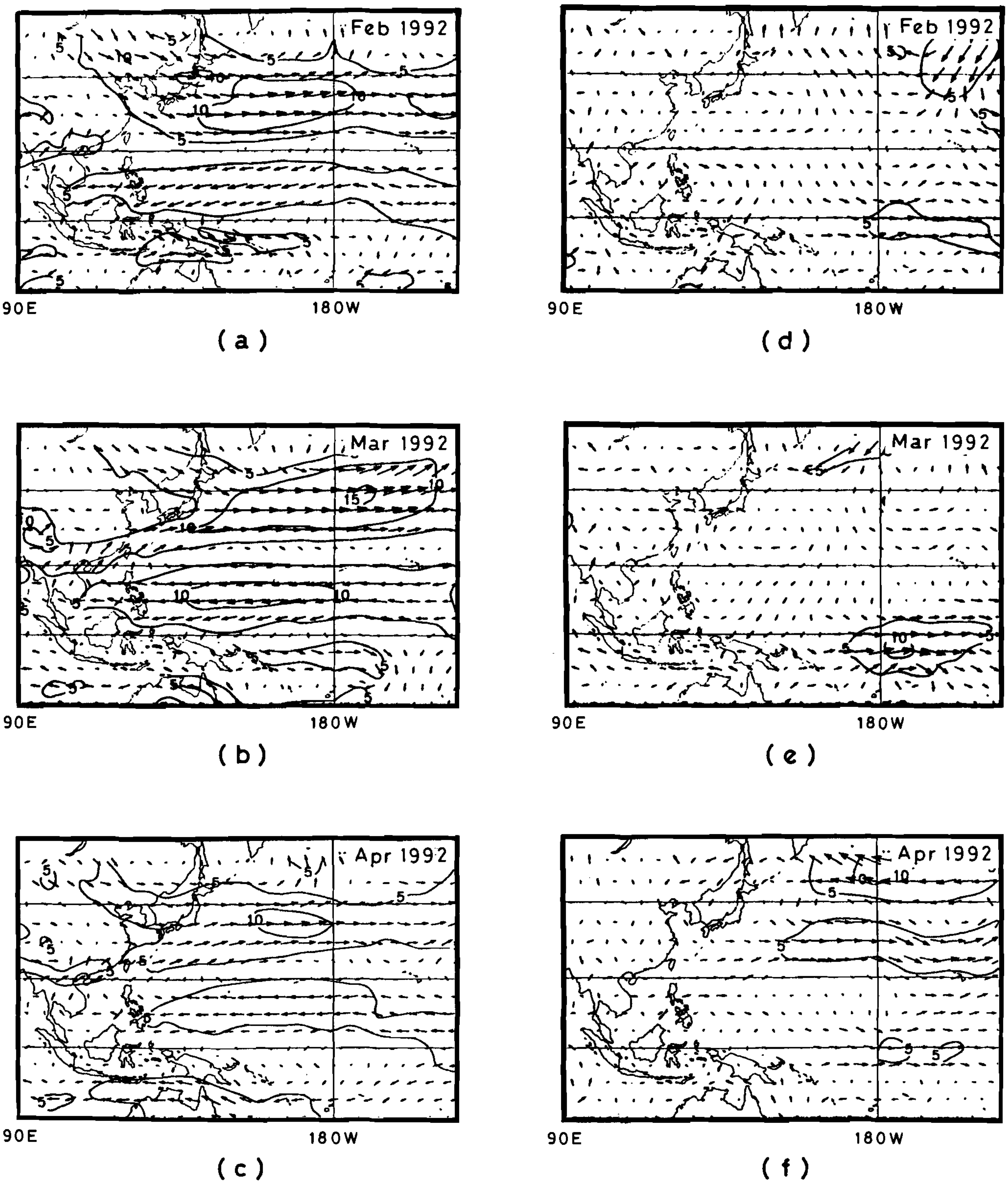

Figure 5 850 hPa streamline charts. (a) - (c): Mean for the indicated month. (d) - (f): Anomaly for the indicated month in terms of departure from the 1979-1988 average. (adapted from Kousky, 1992.)

to some extent account for the positive temperature anomalies observed in Siberia and northern China since there would be no time for cold air to accumulate in the interior of the continent. On the other hand, frequent arrivals of cold air kept the temperatures in southern China below normal values. However, being so frequent, most of the cold air outbreaks were relatively weak and so lacked the strength to displace in depth the warm moist air along the coast of southern China.

In order to gain some insight into the flow in the lower troposphere over Hong Kong, we take a look at the mean 850 hPa streamline charts for February - March 1992 (Figure 5). Throughout the period, Hong Kong was located under a belt of relatively strong southwesterlies, oriented approximately WSW to ENE along the coast of southern China. In terms of anomalies (Figure 5(d)-(f)), the southwesterlies in the vicinity of Hong Kong were stronger than normal and these deviations formed part of an anticyclonic anomaly centred around the Philippines. One might in turn associate this anticyclonic anomaly to the drought conditions in that area. This drought was indicative of large scale descending motion which could be seen as part of the anomalous east-west Walker circulation during the warm phase of ENSO (Julian *et al.*, 1978). The westerly anomaly over the equator near the date-line is yet another key signature of ENSO. Notice that the anomaly peaked in March 1992.

The ENSO Link

The coincidence of the two springs with extreme rainfall in Hong Kong with the occurrence of major ENSO events induced an interest to look into possible link between the two phenomena.

Figure 6 shows the time profile of the standardized monthly rainfall anomaly at the Royal Observatory and the corresponding profile of the Southern Oscillation Index (SOI) based on Kousky (1992) in 1991 and 1992. It is strongly suggestive of Hong Kong rainfall anomalies *responding* to the sharp fall in the SOI during the winter of 1991-92 with a lag of roughly two months. To quantify this observation, another index of ENSO, DT-cap, given in Wright (1989), is correlated with standardized quarterly rainfall figures. In Wright's convention, ENSO events are represented by positive DT-cap values. In the computations, we use the mean value of DT-cap for the months December - February and the rainfall figures in the same quarter and other quarters at 1-, 2- and 3-month lags. The

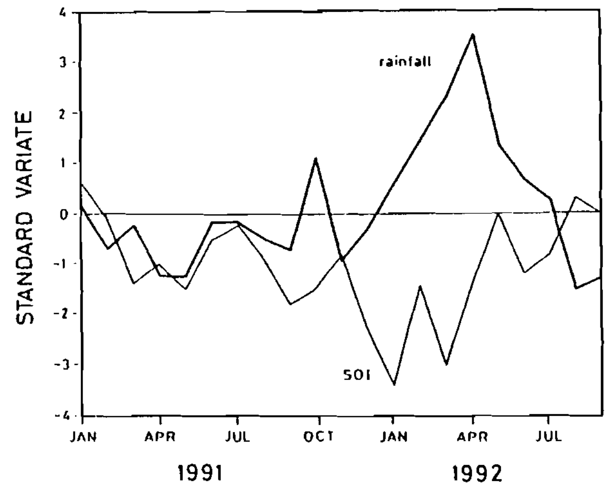

Figure 6 Standardized monthly rainfall anomaly at the Royal Observatory headquarters, Hong Kong, compared with the Southern Oscillation Index given in Kousky (1992).

correlation coefficients are respectively 0.38, 0.66, 0.49 and 0.20. The quarters centred on February or March have higher correlation coefficients which also are significant at the 0.995 confidence level. These results are broadly in line with the work of Ropelewski *et al.* (1987) which showed some ENSO signal in the rainfall over the southern China region, with a maximum positive deviation from normal around February in the year following the ENSO development phase.

We have also computed the composite profiles of standardized monthly rainfall anomalies for ENSO events. Cases with mean (DT-cap) $\geq$ 15 in the months December - February are taken to represent ENSO events. The sample represents roughly the first quintile of DT-cap values in the 100 years studied, i.e. 1884 - 1983. The two year profile of mean DT-cap in ENSO cases, centred on the winter chosen, is shown in Figure 7. On average, in the selected ENSO cases, the index built up gradually during the development phase, the deviation from zero being noticeable by around July and reaching a maximum in winter, followed by a relatively quick fall in the index value the following year. The mean standardized rainfall anomaly profile for the selected ENSO events is shown in Figure 8. There is much month-to-month fluctuation in the rainfall anomalies during the ENSO development phase, that is, as DT-cap values become positive and increase to their peak in winter. However, the rainfall anomaly consistently remains positive over the seven-month period January - July when ENSO reaches its mature phase and begins to decline. Month-to-month fluctuations then

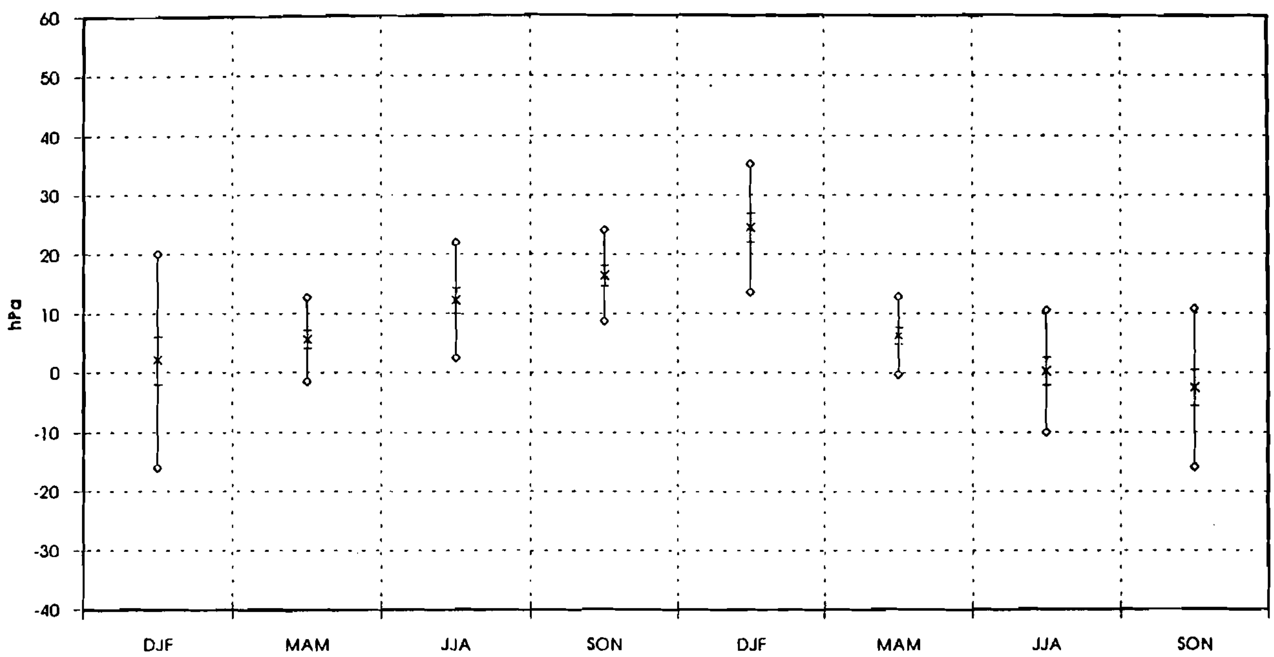

Figure 7 24-month composite profile of DT-cap for ENSO cases in which DT-cap exceeded +15 in December - February. Quarterly mean values are shown. The long error bars represent the standard deviation, the short ones, the standard error. Based on data in Wright (1989) for the period 1884-1983.

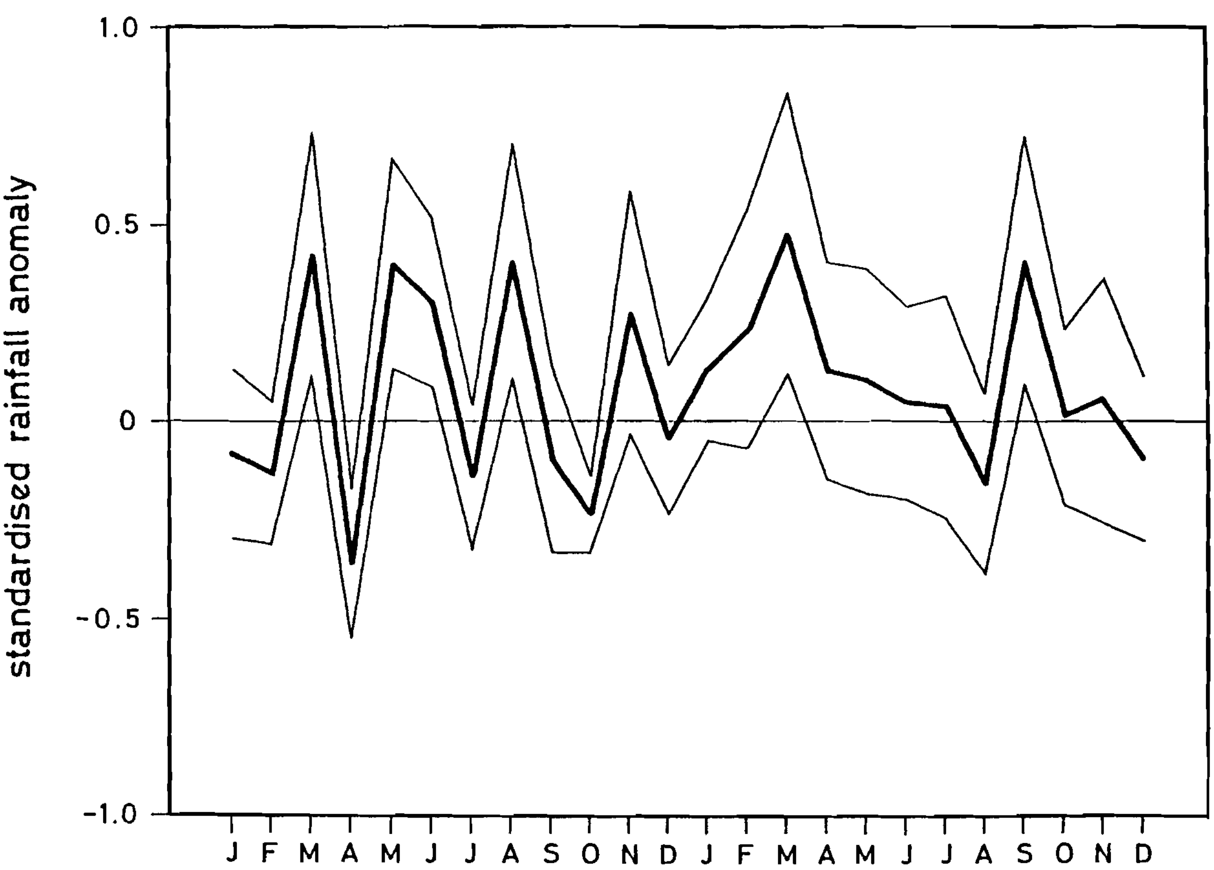

Figure 8 24-month composite profiles of standardized monthly rainfall anomalies for ENSO cases. The thin lines represent ±1 standard error limits. Based on Royal Observatory headquarters rainfall data, 1884-1983.

apparently resume. The positive deviation is most pronounced during the spring months, which happens to reflect generally the rainfall situation in 1992.

We shall now turn to extreme rainfall cases. Since records began in 1884, the rainfall at Royal Observatory headquarters in February - April exceeded 500 mm on nine occasions. Eight of them (1885, 1888, 1926, 1959, 1966, 1983, 1987, 1992) were associated with ENSO events, although the first two were fairly weak ones according to DT-cap values. On the other hand, when years with low spring rainfall were examined, there was no obvious differentiation between ENSO and non ENSO years.

Previous work by Wu *et al.* (1990) and Halpert *et al.* (1992) has shown that the mean temperature in spring in southern China tends to be above-normal during the mature phase of ENSO. The springs of 1983 and 1992 both corresponded to such a phase of ENSO. The observed below-average temperatures during these two springs were therefore out of line with *normal* ENSO expectations. To assess whether indeed wet ENSO springs tend to be cooler than dry ENSO ones, we selected those springs preceded by mean (DT-cap) ≥ 15 in December - February and divided the twenty cases into two equal groups of ten each. The first group contained the ten wettest ENSO springs and the other group contained the rest. The statistics of the mean February - April temperature for the two groups are as follows :

type of spring	mean temperature	standard deviation	standard error
"wet"	18.2°C	1.2°C	0.4°C
"dry"	19.0	1.1	0.4

Therefore, on average, wet ENSO springs did have lower mean temperatures than drier ones.

Conclusions

The springs of 1983 and 1992 in Hong Kong shared much in common : extreme rainfall, humid, gloomy and cooler than normal. Both occurred during the mature phase of a warm ENSO episode.

One might visualize the anomalous weather conditions as the result of the combination of a number of factors. Firstly, during these two springs, the moisture-laden southwesterly airstream in the lower troposphere was stronger than normal. The enhanced strength of the southwesterlies might be related to an anti-cyclonic anomaly at 850 hPa centred near the Philippines. This anomaly could further be understood as a manifestation of the descending branch of the anomalous east-west Walker circulation in the tropical Pacific observed during ENSO events.

Secondly, waves in the mid tropospheric westerlies propagating from west to east across China during the same period brought frequent but weak pulses of cold continental air to the coast of southern China, maintaining below-average temperature there. Under normal circumstances, the prevalence of the continental airmass would have brought fine and dry weather. However on these occasions, the cold air encountered southwesterly airstreams of above-average strength and failed to displace in depth the warm moist airmass near Hong Kong. Along the belt where the two air masses met, the warm moist air rose, giving rise to cloud and rain. The strong contrast between the cool air from the north and the warm moist air from the southwest during these two springs led to conditions more extreme than usual. All through spring in both 1983 and 1992, this belt remained close to Hong Kong, thus accounting for the persistence of rainy and gloomy weather. A schematic diagram showing this rainfall mechanism is given in Figure 9.

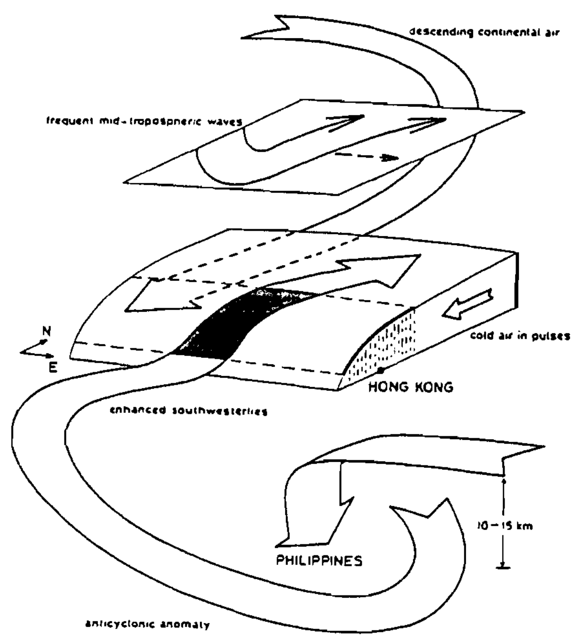

Figure 9 Schematic diagram to illustrate the rainfall producing mechanism in the ENSO springs of 1983 and 1992.

It is not apparent what brought about the occurrence of frequent westerly waves. We note that positive temperature anomalies in northern China and Siberia occurred in the winters of 1982-83 and 1991-92 but such anomalies do not appear to be a regular feature of ENSO (Halpert *et al.*, 1992). The two phenomena *viz.* westerly waves and temperature anomalies might be different facets of a bigger phenomenon but the relationship between the two is not entirely clear. ENSO appears to be a necessary (but not sufficient) condition for the occurrence of extreme rainfall in spring in Hong Kong. A significant positive deviation of the DT-cap parameter from zero, say, around *+10* (*see* Figure 7) in the previous summer may be treated as a precursor signal. At the low end of the spring rainfall range, ENSO does not seem to be a relevant factor.

Statistics strongly suggests correlation between spring rainfall in Hong Kong and indices of ENSO in the preceding winter. Unfortunately, while the correlation coefficients are statistically significant, they are probably not large enough to be useful for operational forecasting. The large percentage of unexplained variance in the rainfall is not surprising since the rainfall amount depends on not just the magnitude of the rain belt but also the position of Hong Kong relative to the belt. The latter factor could produce much scatter in the observed rainfall. Finally we have yet to identify what factor(s) exert influence on the supply of cold air to the northern side of the rain belt.

Acknowledgements

I would like to thank Mr. Wong Siu-Ki, Mr. Wong Chi-Fai, Mr.Tse Wai-Ming and Mr. Choy Boon-Leung for their assistance in data extraction and statistical computations. Mr. Lee Yat-Kwong and Mrs. Ng Chan Kam-Chu helped draft the figures and Miss Frances Chow typed the many drafts of the script before its final form. I would like to thank them all.

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Morning Showers over Hong Kong During Summer

Abstract

During the Hong Kong summer, the hourly occurrence of precipitation shows a maximum at around 0700 local time. This study attempts to investigate the physical processes responsible for producing these morning showers (MS) and to derive a prediction algorithm based on such an investigation.

It is found that the occurrence of MS is a result of the convergence offshore between the land breeze at night and the prevailing large-scale monsoonal flow. Provided enough moisture is present in the lower troposphere such convergence will produce enough convection which leads to shower development. As the land breeze weakens in the early morning hours, the monsoonal flow will advect this line of convection onshore and bring rain to Hong Kong. The weakening of the land breeze also implies a termination of the mechanism for producing such showers. Therefore, the convection diminishes as the day progresses and rain finally stops in the late morning.

Such a mechanism is derived by testing the statistical significance of the wind components at the Royal Observatory (RO) and Waglan Island (WL), the dew point temperatures within various layers in the low to mid troposphere as well as the atmospheric stability. Parameters found to be significant include the meridional components at the RO and WL and the mean dew point temperature between 1000 and 700 hPa. A flowchart is developed using these parameters to predict the occurrence of MS. The results for the dependent sample give a much better prediction than random chance and produces a skill score of 0.43. Thus, such an algorithm can be tested operationally for its utility.

Introduction

During the summer (1 May to 31 August) in Hong Kong, showers occur quite frequently due to the high temperature, availability of a large amount of moisture and the existence of conditional instability in the atmosphere. An examination of the frequency distribution of the hourly occurrence of rainfall suggests that in the early morning (especially at local time 07), rain is more likely to occur (Figure 1). Such a diurnal variation of rainfall events is obviously related to local effects. It is therefore of interest to study the conditions under which showers are more likely to occur during the morning hours.

In order to isolate these conditions from those which may bring about shower activity (*e.g.* large-scale disturbance, tropical cyclones or daytime heating), the following definition is used in this paper to define the occurrence of a morning shower :

> Whenever measurable rainfall, including trace, was recorded at the Royal Observatory Hong Kong (RO) ending on the hour between local time 0500 and 1000 but no rain occurred for the rest of the day, this type of rain event will be defined as a morning shower (MS).

The purposes of this study are (a) to identify the physical mechanisms governing the formation and development of MS over Hong Kong during the summer months, and (b) to develop forecast rules to predict the occurrence of this type of rain event.

The possible physical mechanisms for such an occurrence are given in the next section. The data and methodology used to test this hypothesis

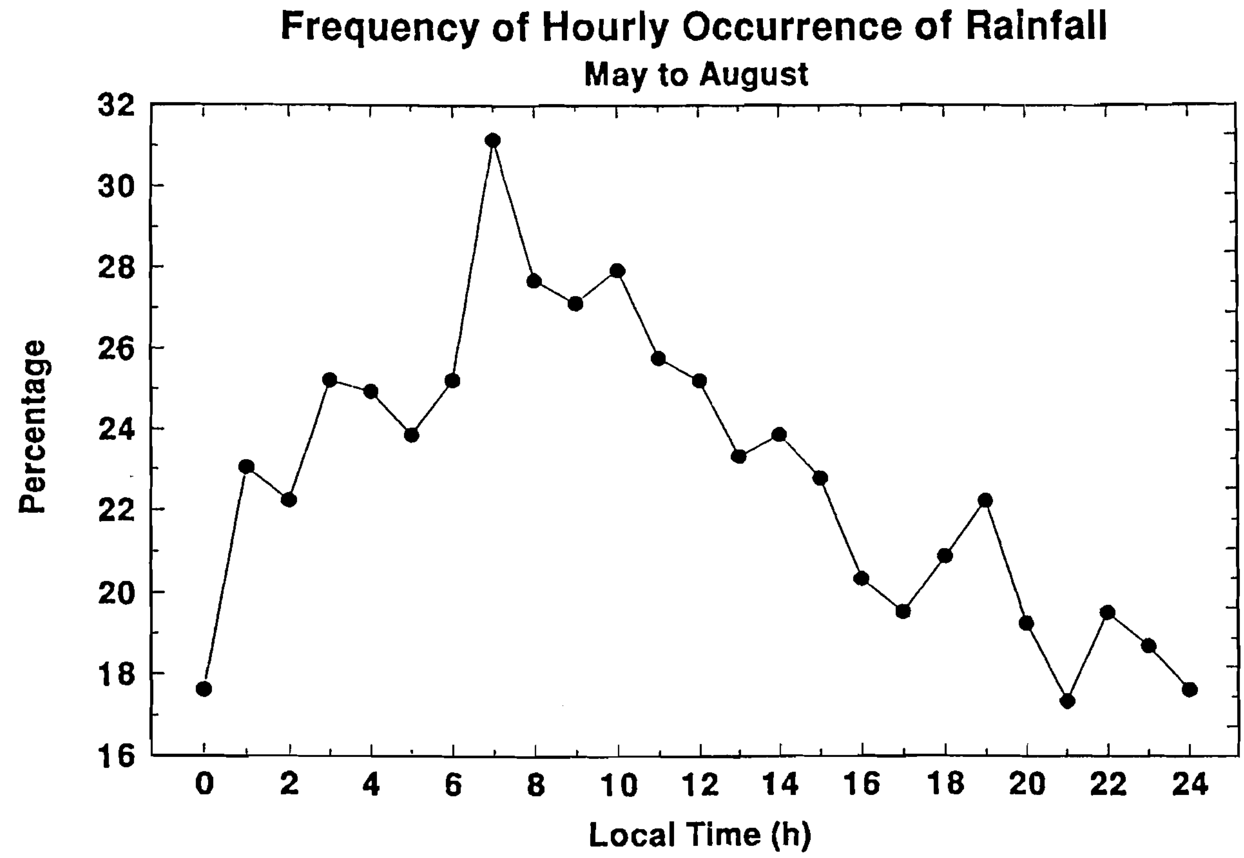

Figure 1 Frequency distribution of the hourly occurrence of rainfall at the Royal Observatory, Hong Kong during the months May through August. The sample contains data between 1988 and 1990.

are then described in the following section, together with some statistics on these rain events. Various parameters which could help formulate the physical mechanisms are analyzed in the section after that. Those parameters found to correlate significantly with the occurrence of MS are then combined in the following section to develop a decision-tree flowchart for prediction. A summary of the results is given in a final section.

Mechanism for the Occurrence of Morning Showers

Local meteorologists have long been aware of the occurrence of morning showers in Hong Kong during the summer although no detailed study about this phenomenon has been made. In other tropical coastal areas like Dar es Salaam in Tanzania, East Africa in which the land-sea breeze circulation can reach a significant extent, evidence of morning storm activity has also been established (Sumner, 1988). The maximum rainfall activity occurs in the early morning (around local time 0500 - 0600) but settles down soon after sunrise. This phenomenon results from the diurnal variation of the strength of the land breeze which shows a maximum intensity in the late night and early morning. Thus, it seems reasonable to assume that the development of MS over Hong Kong is related to the land/sea-breeze circulation.

A seasonal variation of this morning storm activity over Dar es Salaam also exists in response to the pronounced seasonal variation in the prevailing wind direction. Morning showers tend to occur more often when northeast trade winds prevail in January and February. Among the other months when southeasterlies prevail, rainfall occurs mainly in the middle of day corresponding to the time of maximum local heating. Since MS over Hong Kong occur only during the summer months, their development may be related to the large-scale prevailing monsoonal winds.

Thus, it appears that MS over Hong Kong during the summer probably result from the interaction between the large-scale monsoonal flow and the local-scale land breeze. Specifically, as the land breeze develops and gains strength during the night, it converges with the large-scale monsoonal flow to form a line of convergence offshore. If the atmosphere is conditionally unstable and the convergence is strong enough, convection will occur with a subsequent development of showers. In the early morning hours when the land breeze begins to weaken, this line of convection is then advected towards land by the large-scale monsoonal flow and brings rain to land stations in the morning. However, the weakening of the land breeze also means the main mechanism for maintaining the convection (*i.e.* the low-level convergence) no longer exists. The line of clouds eventually dissipates as the day progresses.

In order to test the validity of this hypothesized mechanism, various parameters related to the stability of the atmosphere and the convergence between the two air streams need to be analyzed. These are described in the next section.

Data and Methodology

Data

All the data used were kindly provided by the Royal Observatory, Hong Kong (RO) and the period selected is between 1988-1990. Tao and Chen (1989) suggest that the average onset date of the summer monsoon along the South China coast is May 10. This implies that the large-scale southwesterlies begins to dominate from May onwards. Thus, the period from May to August is chosen to analyze the contribution of the large-scale monsoon to the formation of MS.

To represent the large-scale flow, surface winds measured at Waglan (WL) Island, a small island in the southeastern part of Hong Kong, are used. On the other hand, since the RO is located in Tsim Sha Tsui and land-locked to the north, the surface winds at this station may be taken as the local wind. As for the atmospheric stability and moisture content, the upper-air sounding taken at King's Park at 2000 local time (LT) is analyzed.

The rainfall data consist of the total amount of rainfall measured at the end of every hour at the RO. Based on the definition of MS given in the Introduction, a total of 38 cases are identified within the 369 days in the data sample. The monthly distribution of these cases is shown in Table 1. It can be seen that morning showers occur more frequently in May and July. The monthly distribution of rainfall in Hong Kong has a bimodal structure, with one peak in June and the other in August. The first is attributed to disturbances from the summer monsoon while the second is mainly due to the passage of tropical cyclones (Chan, 1989). Therefore, we may say that morning showers are more likely to occur when the influence of large-scale disturbances is small.

Table 1 The monthly distribution of morning showers during the summers of 1988-90.

Year	May	June	July	August	Total
1988	5	3	6	2	16
1989	6	4	1	1	12
1990	0	0	5	5	10
Total	11	7	12	8	38

When a synoptic-scale weather system (monsoon trough or tropical cyclone) is likely to affect the South China coast, MS are generally not anticipated. These cases should not be included in the data sample of days without MS. Therefore, those days during which rainfall occurred throughout most of the day were excluded. In addition, no upper-air data were available in seven of the remaining days. Thus, the sample now contains 38 cases with MS and 98 cases without, giving a random chance of occurrence of about 28%. Any prediction must therefore have a higher percentage of success than this value.

The distribution of the amount of rainfall associated with MS and their duration are shown in Table 2. It can be seen that typically, the amount of rain is within 1 mm occurring during a span of 1 to 2 hours.

Table 2 Distribution of amount of rainfall of MS and distribution of duration of MS recorded at RO.

Amount (mm)	<0.1	0.1-1.0	1-5	5-10	10-20	>20
No. of days	21	8	6	1	1	1
Duration (hr)		1	2	3	4	5
No. of days		13	16	4	4	1

Determining the significance of a parameter

As mentioned in the previous sub-section, the data set is divided into two parts, one associated with MS (38 cases) and the other without (98 cases). Since the sample size is greater than 30, the distribution of the parameters in both data samples may be assumed to be normal. For each parameter which is likely to have substantially different values between the two samples, the mean and standard deviation of the parameter in each set are first calculated. The standard deviation (σ) of the combined data set can be computed using

$$\sigma^2 = \frac{\sigma^2_{MS}}{n_{MS}} + \frac{\sigma^2_W}{n_W}$$

where n is the sample size and σ the standard deviation. The subscripts MS and W denote the sample with and without morning showers respectively.

To determine the level of significance of a parameter X, the ratio of the difference of this parameter between the two samples

$$X\ (= X_{MS} - X_W) \text{ and } \sigma$$

is calculated and then compared with standard statistical tables (*e.g.* Spiegel, 1982). For example, a ratio of 1.96 suggests that the level of significance is 0.025. In other words, the parameter X is significantly different between the two samples with a 97.5% confidence.

Choosing a threshold value for prediction

Once a parameter is determined to be significant at least at the 0.025 level, it is chosen as a predictor. Different values of the parameter are then used to make predictions for the occurrence of MS using the dependent sample. A 2 x 2 contingency table can then be formed. Two pieces of statistic can be used to evaluate the accuracy of the predictions. One is the value of χ^2. Any prediction with a χ^2 value greater than that given by random chance can be considered to be significant.

The other statistic is the skill score S (Panofsky and Brier, 1958) which is defined as

$$S = \frac{R - E}{T - E}$$

where R is the number of correct forecasts, T the total number of forecasts and E the number expected to be correct based on some standard which is chosen to be random chance in this case. The higher the skill score is, the better is the prediction. Therefore, the final value of the parameter is determined by numerous attempts to achieve a high skill score while making sure that the value of χ^2 is significant.

Analyses of Potential Predictors

Surface winds

In this section, the relationships between the occurrence of MS and the large-scale surface wind (as represented by that at Waglan Island, WL), the local surface wind (as represented by that at RO) as well as the convergence between these two flows are investigated.

During the days without MS, a diurnal variation of the meridional wind clearly exists at RO and especially at WL (Figure 2). Such a variation is obvious due to the land-sea breeze effect. That is, the sea breeze during the day enhances while the land breeze at night reduces the strength of the large-scale southerly flow. Comparing the winds at the two stations, the diurnal variation at RO is smaller which may be due to the stronger surface friction over land.

During the days preceding MS, the situation is quite different (Figure 3). At WL, the southerly winds remain rather steady throughout the night and weaken only for a brief period in the morning. At RO, the amplitude of the diurnal variation as well as the magnitudes of the southerly wind are also larger.

Two conclusions can be drawn from Figures 2 and 3. First, on nights preceding the occurrence of MS, the mean wind speeds in the meridional direction at both WL and RO are greater than on nights without. At WL, the difference becomes large at 2000 LT and continues until the morning (about 0900 LT) while at RO, this difference reaches a maximum between 2200 and 0200 LT. The wind speeds within these two time ranges can therefore be used to relate the effect of low-level winds on the occurrence of MS. For the purpose of prediction, the range should be chosen with the ending hour well before the start of the MS. Therefore, wind speeds between 2000 - 0300 LT and 2200 - 0200 LT have been chosen for WL and RO respectively.

Second, it is obvious from Figures 2 and 3 that the difference between the meridional wind speeds at these two stations is greater on the nights preceding the occurrence of morning

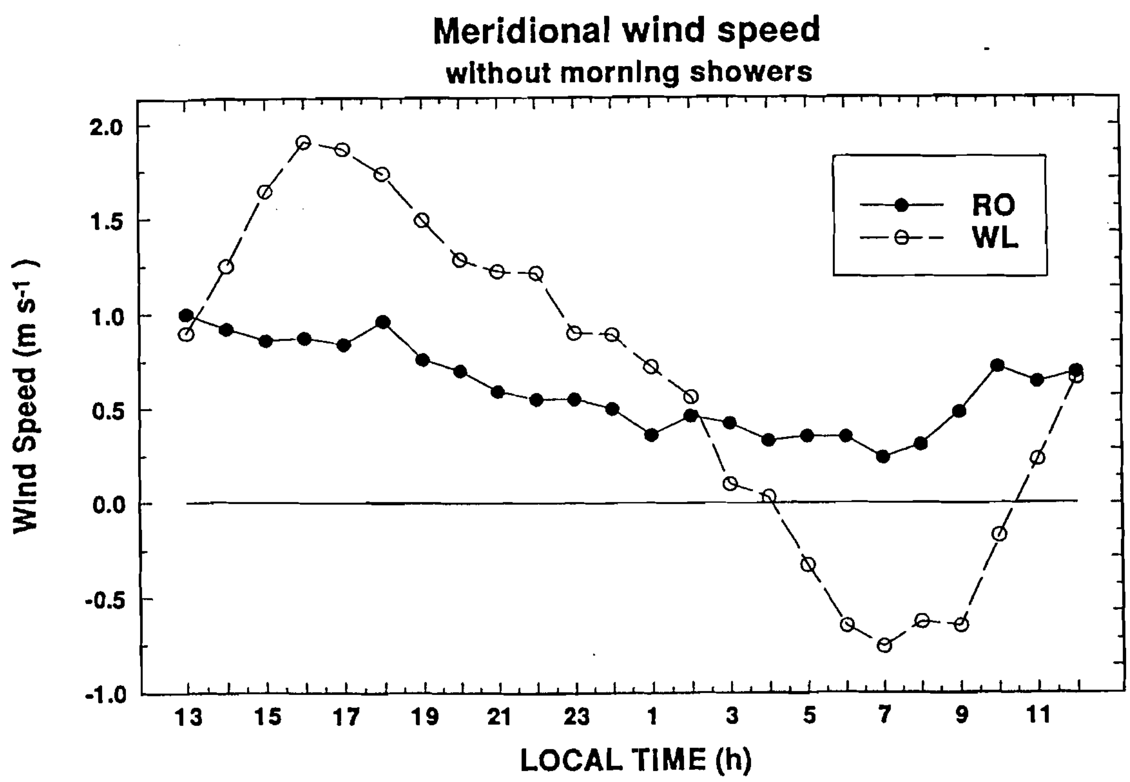

Figure 2 Mean meridional wind speeds at RO and WL during days without MS

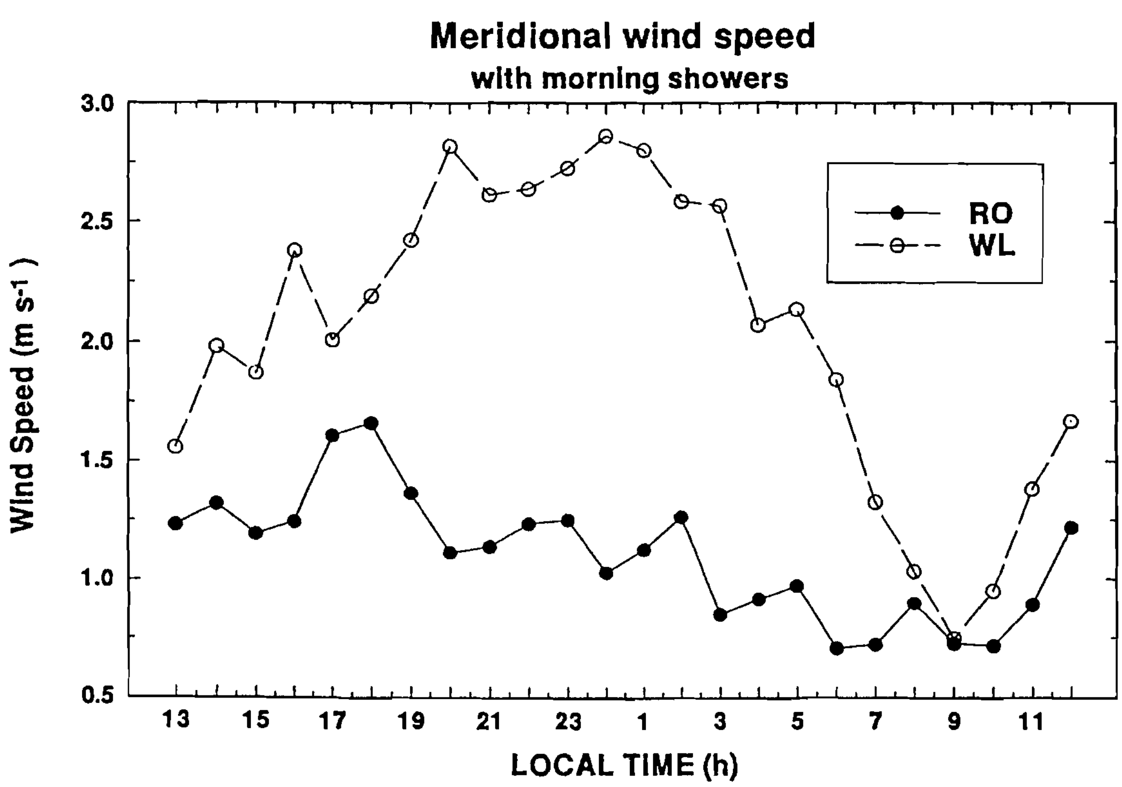

Figure 3 Mean meridional wind speeds at RO and WL during the days with MS. The time is from 1300 local time on the day preceding the occurrence of morning shower.

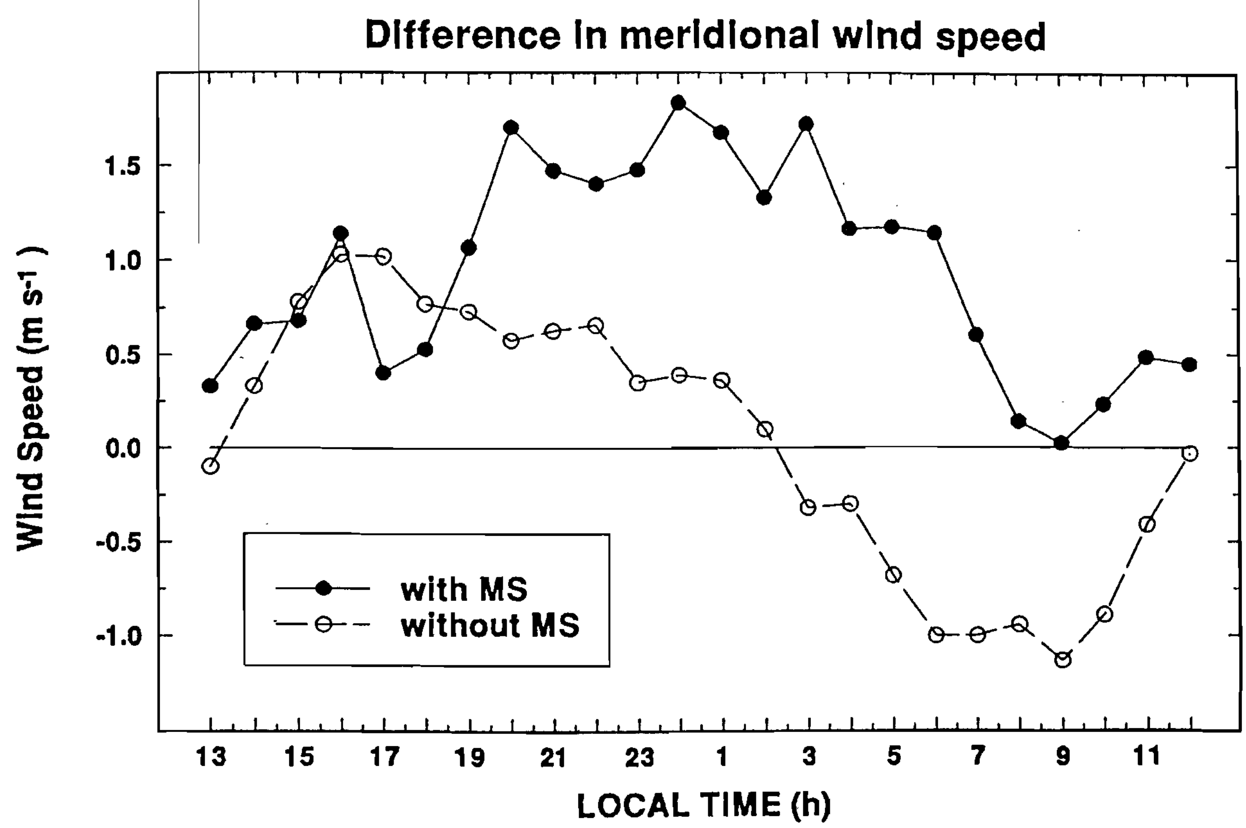

Figure 4 Difference in the mean meridional wind speeds between WL and RO (Diff) with and without MS.

showers, as can be seen from Figure 4. Magnitudes of more than approximately 1.5 m s^{-1} are observed between 2000 and 0300 LT. This difference in fact represents the convergence between the large-scale flow and the local land breeze. As will be seen below, this difference is statistically significant. Therefore, the convergence of these two flows is a major contributing factor in the formation of MS.

Convergence of the zonal components has also been analyzed. However, the mean difference is not significant at the 5% level. This result suggests that the zonal winds need not be considered in predicting the occurrence of MS.

Statistics on the three relevant wind parameters (RO, WL and Diff (=WL-RO)) are shown in Table 3. The common period 2200 - 0200 is chosen because the mean values within this period show the highest level of significance. It can be seen that the difference in the mean meridional wind speeds at the RO between the two samples has the highest level of significance (<0.05%). The other two parameters are also significant at least at the 2.5% level.

Table 3 Statistics of the meridional wind data on days with and without MS. RO and WL are the average wind speeds within the local time 2200-0200 at RO and WL respectively, Diff = WL - RO, σ the combined standard deviation, and σ_{MS} and σ_w are as defined. Unit : m s^{-1}.

	Wind Parameter		
	RO	WL	Diff
MS mean	1.17	2.72	1.55
σ^2_{MS}	1.06	11.53	7.66
Without MS mean	0.48	0.85	0.39
σ^2_w	0.51	9.32	6.27
Difference in mean	0.69	1.87	1.16
Combined σ	0.18	0.63	0.51
No. of σ different	3.83	2.97	2.27

Table 4 Prediction of the occurrence of MS based on the three wind parameters WL, RO and Diff (see Table 3 for definitions). The cut-off criterion is based on the difference in the mean values between the two samples.

	Wind Parameter		
	RO	**WL**	**Diff**
Cut-off criterion (m s^{-1})	1.17	2.72	1.55
No. of cases predicted	27	52	54
No. of correct predictions	17	24	23
Percent correct	63	46	43
χ^2	22.59	16.06	11.42
Skill score	0.379	0.311	0.256

Based on these results, predictions on the occurrence of MS can be made using each of the three parameters. The results of such predictions on the dependent sample are shown in Table 4. The skill score of RO is the highest among the three parameters. In addition, the 27 cases correctly predicted using the RO parameter are also included in the 52 cases of WL. This suggests that a strong wind at RO implies strong wind at WL as well. It may be concluded that the occurrence of MS depends on the strong onshore (large-scale) wind.

The reason why the RO parameter gives a higher skill score than the WL parameter may be as follows. A strong wind measured at RO implies that even with friction over land, the strong southerly flow can be felt at this land station. This implies that this large-scale flow is indeed very strong, which is necessary for advecting the offshore convective activity onshore. On the other hand, the cut-off speed of 2.7 m s^{-1} at WL may not imply strong enough a wind speed to allow such an advective process to take place. As the parameter Diff is calculated from the difference between WL and RO, a lower skill score of WL gives a corresponding lower score of Diff.

Since all three parameters give much better forecasts than random chance (which has a value of χ^2 = 7.88), they can be used in predicting the occurrence of MS. These parameters will be combined with others in the next section to obtain an even better forecast.

Moisture availability

To determine the effect of humidity on the occurrence of MS, dew point temperatures at various levels in the low to mid troposphere are analyzed. Table 5 shows the statistics of average dew point temperatures in different layers of the atmosphere at 2000 LT.

Table 5 Average dewpoint temperature (°C) between 1000 hPa and various pressure levels at 2000 HKT on days preceding morning showers and those without. See Table 3 for explanation of the symbols.

	Pressure level (hPa)				
	500	**600**	**700**	**800**	**900**
MS mean	6.88	12.30	15.76	18.81	22.10
σ^2_{MS}	6.25	3.01	3.34	1.65	1.51
Without MS mean	4.92	10.30	13.36	17.42	21.27
σ^2_W	22.48	19.69	22.02	10.9	25.10
Difference in mean	1.96	2.00	2.40	1.39	0.83
Combined σ	0.63	0.53	0.56	0.39	0.30
No. of σ different	3.11	3.77	4.29	3.56	2.77

It can be seen that the most significant difference between the two samples exists in the layer between 700 and 1000 hPa where the difference in the mean dew point temperature is 4.29σ. Such a result is reasonable since the moisture in the entire lower troposphere must be high enough to maintain the convection.

Table 6 As in Table 4 except for the mean dew-point temperature within the 1000-700 hPa layer (Atd7).

Cut-off criterion Atd7 >	13.36 °C
No. of cases predicted	93
No. of correct predictions	37
Percent correct	39.8
χ^2	23.8
Skill score	0.279

Using the results in Table 5, predictions can be made with the values of the mean dew point temperatures within the layer 1000 - 700 hPa (Atd7). Various cut-off points have been tested and the best skill score is to use the mean value for the without-morning-shower sample, *i.e.* 13.36°C. The results of the prediction are shown in Table 6.

The skill score is less than those using the wind parameters. Nevertheless, since these are independent variables, they can be combined to make a better prediction, as will be seen in the next section.

Atmospheric stability

Besides the availability of moisture, the atmosphere must be at least conditionally unstable in order for convection to occur. Therefore, the stability of the atmosphere should be different between the two samples.

Various empirical indices have been developed to represent atmospheric stability. Among these, the K-index (George, 1960) and the Total Totals (Miller, 1972) are used. The K-index is defined as

$$K = (T_{850} - T_{500}) + T_{d850} - (T - T_d)_{700}$$

where T is the temperature and T_d the dew point temperature. The number subscripts indicate the pressure level at which the temperature is measured. The first term gives the lapse rate in the lower troposphere while the second and third terms represent the moisture availability. According to George (1960), isolated thunderstorms typically occur when K > 20. As K increases, the chance of severe convection also increases.

The Total Totals (TT) index is similar to the K-index and is defined by

$$TT = VT + CT$$

where

$$VT = T_{850} - T_{500},$$

$$CT = T_{d850} - T_{500},$$

and the symbols have the same meanings as those for the K-index. The sub-parameters VT and CT are known as the Vertical Total and the Cross Total respectively. Typical values for thunderstorms are VT > about 26 and CT > about 18, *i.e.* TT > about 44.

The four parameters (K-index, VT, CT, TT) are computed for all the cases in the two data samples and the results are given in Table 7. It can be seen that other than VT, all other indices are significant above the 0.025 level. Since TT is related to VT, the contribution of the latter would reduce the significance of the former. Therefore, it seems that only CT would be useful. This result again appears to be reasonable because VT represents the lapse rate of the lower to mid troposphere which is essentially the same throughout the summer when large-scale disturbances are absent. In fact, a comparison between the two samples of the lapse rates for different layers of the low to mid troposphere shows that they are not significantly different (not shown).

Table 7 ***K-index and Cross, Vertical and Total Totals during days with and without MS. The values are calculated using the 2000 LT upper-air sounding the day before. See Table 3 for an explanation of the symbols.***

	Stability index K-index	VT	CT	TT
MS mean	30.00	23.19	19.02	42.21
σ^2_{MS}	22.86	1.44	4.19	5.36
Without MS mean	27.09	23.41	16.90	40.32
σ^2_{W}	109.53	3.19	20.72	26.07
Difference in mean	2.91	0.22	2.12	1.89
Combined σ	1.30	0.26	0.57	0.64
No. of σ different	2.24	0.85	3.72	2.95

This lack of difference in the lapse rates between the two samples also affects the performance of the K-index as a predictor. Predictions using the K-index give values of χ^2 lower than that of random chance. Therefore, the only stability index that can be used is the cross-total which gives a reasonable skill score (Table 8).

Summary

The results in this section essentially demonstrate the validity of the physical mechanism discussed earlier. That is, the occurrence of morning showers results from the convergence between the land breeze and the large-scale monsoonal flow. As a land breeze

Table 8 As in Table 4 except for the Cross Total (CT) stability index.

Cut-off criterion Atd7 >	19.02 °C
No. of cases predicted	50
No. of correct predictions	21
Percent correct	42
χ^2	9.38
Skill score	0.234

generally exists whether MS occurs or not, the convection which develops on days with MS must depend on a strong monsoonal flow. The resulting strong convergence at low levels then forces the moist air to rise beyond the level of free convection. The convection can be maintained if the moisture content of the low to mid troposphere is high and the atmosphere is unstable (as demonstrated by the significance of the mean dew point temperature between 1000 and 700 hPa and the value of the cross total). The strong monsoonal winds (significance of the RO and WL winds) then advect the convection towards land as the land breeze weakens in the early morning hours.

In the next section, these parameters will be combined to give a prediction for the occurrence of morning showers.

Prediction of the Occurrence of Morning Showers

Five parameters have been found to be significantly related to the occurrence of morning showers. Predictions using each individual parameter yields skill scores of between 0.234 and 0.379. These are summarized in Table 9.

The forecast algorithm (Figure 5) starts by using the predictor with the highest skill score, *i.e.* meridional wind speed at RO. If this value exceeds the critical value given in Table 9, then the value of Atd7 is tested. If the latter also exceeds the critical value, then MS is predicted. Of the 21 cases predicted, 16 cases did have MS. If the value of Atd7 is less than the critical value, then MS is predicted not to occur. Only one out of these six cases had MS.

Table 9 Cut-off values of significant parameters for the prediction of occurrence of morning showers and the corresponding skill scores. The definition of these parameters are given in the previous section.

Parameter	Cut-off value	Skill score
RO (m s^{-1})	1.17	0.379
WL (m s^{-1})	2.72	0.311
Diff (m s^{-1})	1.55	0.256
Atd7 (°C)	13.36	0.279
CT (°C)	19.02	0.234

If the value of the meridional wind speed at RO is less than the critical value, that at WL is examined since it has the second highest skill score. If the latter is also below its critical value, then no MS is predicted. No further testing is done using the other predictors because the number of false alarms cannot be reduced.

If the value of the meridional wind speed at WL exceeds the critical value, the value of Atd7 is then tested. MS is predicted if this latter value exceeds its critical value. Otherwise, no MS is predicted.

By combining all the predictions, a contingency table can be set up, as given in Table 10. The skill score of this prediction is 0.425 which is higher than any of that in Table 9. Thus, by combining the wind and moisture parameters, a better prediction can be made. Note also from Figure 5 that the CT predictor is not used because it does not contribute to a further improvement in the forecasts.

Table 10 Contingency table for predicting the occurrence of MS based on the flowchart in Figure 5.

	Observed		
Forecast	MS	no MS	Total
MS	23	17	40
no MS	15	81	96
Total	38	98	136

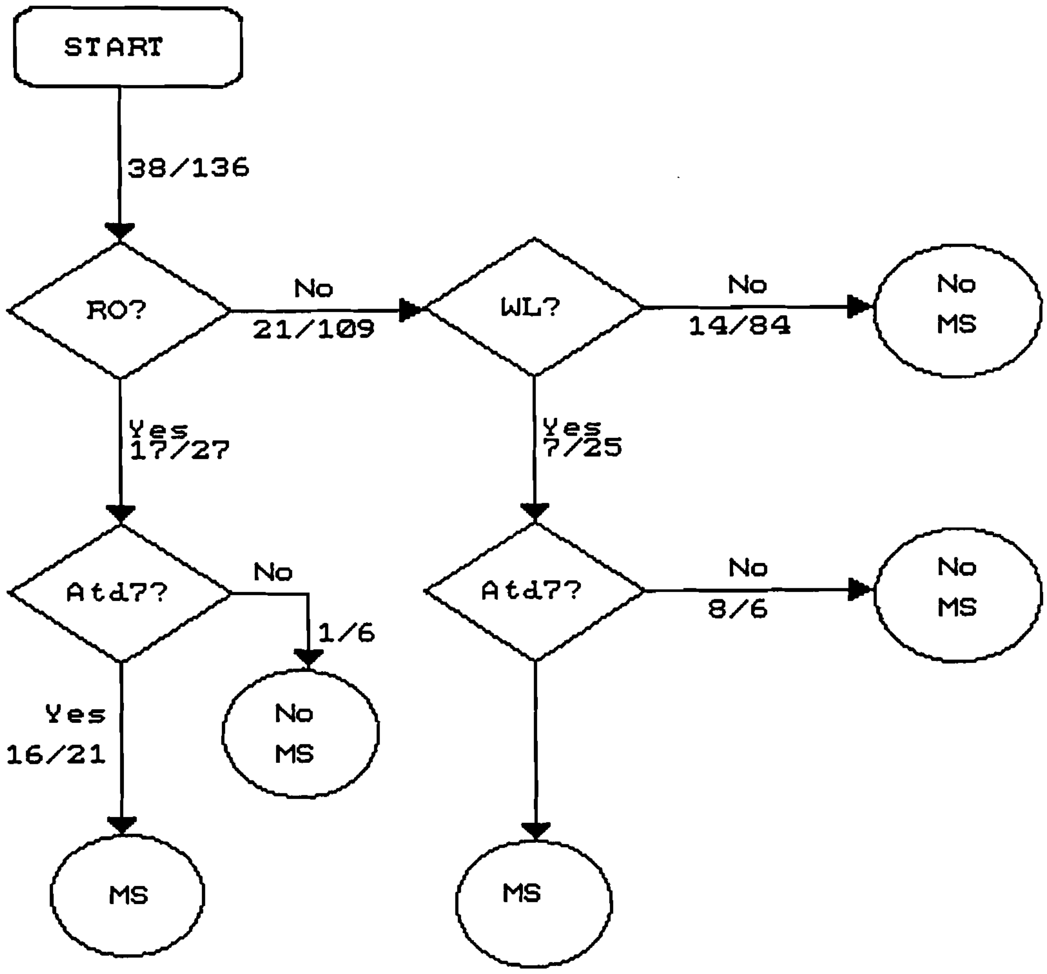

Figure 5 Flowchart of the algorithm used to predict the occurrence of MS. The two numbers along each arrow o/t indicate the number of cases of observed MS (o) and the total number from that condition (t).

rather high false alarm rate (17 out of 40 or 42.5%). If the WL parameter is not used in Figure 5 as a prediction parameter, *i.e.* MS is predicted not to occur if the RO parameter is less than the critical value irrespective of the value of the WL parameter, then the false alarm rate is reduced to 24% (5 out of 21 - see Table 11). The numbers shown in Table 11 give a skill score of 0.429 which is identical to that obtained from those in Table 10.

Since this result is derived from the dependent sample, which scheme works better needs to be tested. In any case, either case shows that by combining the winds and the moisture parameter, a rather good prediction of the occurrence of morning showers can be made.

Table 11 As in Table 10 except only parameters RO and Atd7 are used. See text for further details.

Forecast	Observed MS	Observed no MS	Total
MS	16	5	21
no MS	22	93	115
Total	38	98	136

Summary and Conclusions

The occurrence of morning showers over Hong Kong during the summer months has been found to be a consequence of the convergence between the prevailing southerly monsoonal flow and the local land breeze. Excluding other rain events, the probability of such an occurrence morning showers is about 28 percent. Although the large-scale low-level flow in the summer has a general southerly component, it has to reach a certain strength before morning showers can be observed for two reasons. A strong southerly flow can produce enough convergence with the land breeze in the early morning hours for convection to develop offshore. Such a flow is also necessary to advect the convection inland when the land breeze weakens just before sunrise. Thus, the most important factor is the strength of the southerly flow. Using this single parameter for prediction produces a skill score of 0.38.

In order for convection to develop, enough moisture must be available in the lower troposphere. Therefore, if the average dew point temperature within the 1000-700 hPa layer is included in the prediction, the skill score increased to 0.43. Although the stability of the lower troposphere is also found to correlate with the occurrence of the morning showers, inclusion of this parameter does not improve the prediction. This is probably because conditional instability generally exists over Hong Kong in the summer.

A prediction algorithm has been developed using the meridional winds measured at the Royal Observatory and Waglan Island between 2200-0200 hours local time as well as the average dew point temperature within the 1000-700 hPa layer at 2000 local time. Such an algorithm accurately predicts 23 out of the 38 cases observed but does produce 17 false alarms. By using the moisture parameter and only the meridional winds at the RO, the false alarm rate is reduced to 24 percent while maintaining the same skill score. This further substantiates the importance of a relatively strong southerly wind. It is proposed that each of these two algorithms be tested operationally to determine the validity of these conclusions. Other parameters should also be sought to improve the prediction.

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Tropical Cyclone Generated Wave Spectra at Waglan Island

Wave spectra are useful in many aspects of coastal engineering. For the South China coast, tropical cyclone generated wave spectra have been derived by Chen (1979), Cheng (1986), Poon (1988), Chen *et al.* (1990), and Li *et al.* (1991). This note gives an example each of the shallow water, double-peaked and deep water spectra obtained at Waglan Island during the respective passages in the South China Sea of Severe Tropical Storm (S.T.S) Nathan in June 1990, Typhoon (T.) Zeke in July 1991 and S.T.S. Brendan also in July 1991. Figure 1 shows the tracks of these tropical cyclones, details of which can be found in the Royal Observatory's *Monthly Weather Summary* for the relevant months.

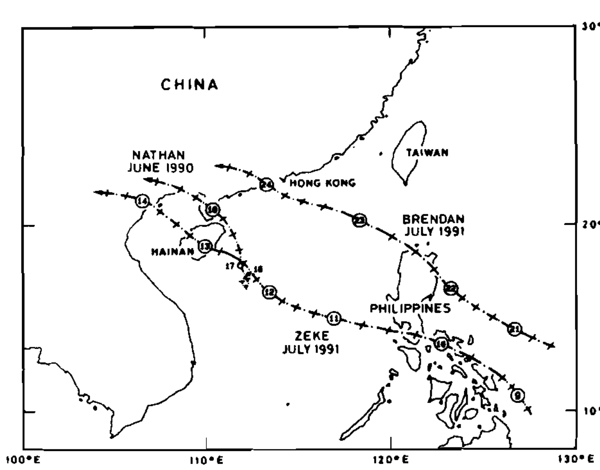

***Figure 1.** The tracks of S.T.S. Nathan, T. Zeke and S.T.S. Brendan. Numbers along the tracks are dates of the months.*

The wave recorder is of the acoustic type, lying off Waglan Island and on the sea bed at about 28 m below mean sea level. Spectral densities are calculated using FFT via IMSL's subroutine SSWD and the Tukey-Hamming window. 960 data points are used in the computations for the first two storms, and 420 for the third. These correspond to 16 and 7 minutes of data respectively, the sampling rate being 1 Hz. Noise in the data is removed by a first order median filter (Brock, 1986), and where the wave record is particularly noisy, also by eye.

The spectral density of the waves generated between 10.30 p.m. HKT and 10.46 p.m. HKT on June 17, 1990 by S.T.S. Nathan is shown in Fig. 2. It is single peaked with the peak frequency f_m at 0.12 Hz (8 to 9 s). The high frequency side has a $f^{-3.3}$ dependence, where f is the frequency, suggesting that for this case the waves are those of finite depth (Kitaigorodskii *et al.*, 1975). This spectrum fits reasonably well the TMA shallow water spectrum proposed by Hughes (1984).

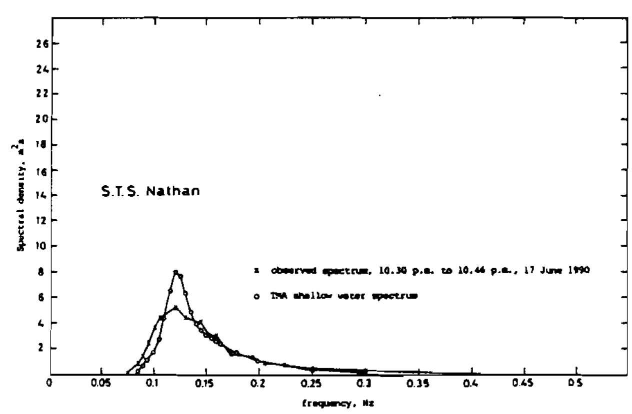

***Figure 2.** Wave spectrum of S.T.S. Nathan. The significant wave height was 2.7 m. Nathan was closest to Hong Kong at around midnight HKT on 17 June, 1990 when it was about 390 km to the southwest.*

Zeke's spectral density (Figure 3), as calculated from Waglan's wave record between 10.30 p.m. HKT and 10.46 p.m. HKT on 12 July, 1991 shows two peaks. The larger peak is around 0.11 Hz (about 9 s), and the smaller peak is at 0.18 Hz (5 to 6 s). Without directional information the origins of the two peaks are difficult to identify. A possibility is that the first peak is due to waves generated by winds nearer the centre of Zeke which at that time was about 520 km to Hong Kong's south-southwest and travelling up to arrive at Hong Kong as swell, and the second to waves generated by local winds which were mainly from the northeast with speeds of about 10 m s^{-1}.

The closest approach of Brendan to Hong Kong was at about 4 a.m. HKT on July 24, 1991, when it passed about 80 km to the territory's south-southwest. The wave spectrum (Figure 4), calculated from measurements made about four and a half hours later, is single peaked with f_m at 0.155 Hz (6 to 7 s) rather than multi-peaked as would have been expected from waves generated so near the centre of the storm. The Pierson-Moskowitz (P-M) / Bretschneider spectral form with a f^{-5} dependence for the high frequency range seems to describe Brendan's spectrum well.

The reasons for the wave spectra of different shapes merit further investigation, but is beyond the scope of this note.

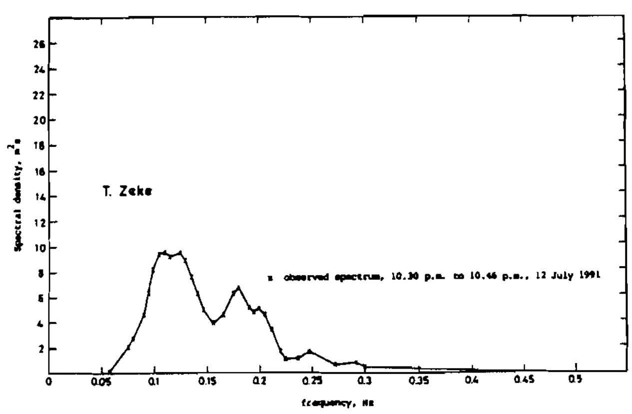

Figure 3. Wave spectrum of T. Zeke.
The significant wave height was 2.5 m.

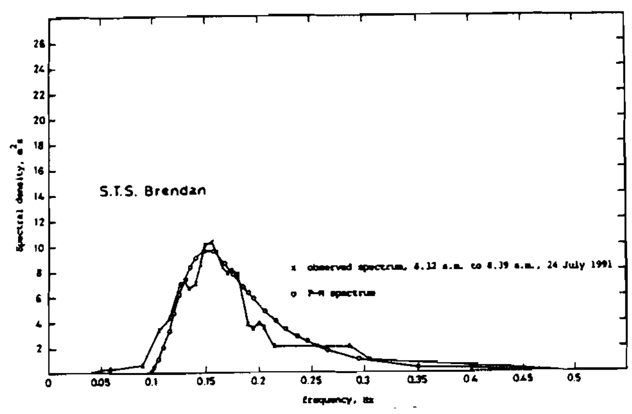

Figure 4. Wave spectrum of S.T.S. Brendan.
The significant wave height was 2.9 m.

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News and Announcements

This section is intended for dissemination of news and announcements by the Society or any of its members. If members wish to relay any news or make any announcement of interest to members which is related to the aims of the Society they should mail or fax such information to the Editor-in-chief along with their name(s) and membership number(s).

FOURTH HONG KONG METEOROLOGICAL SOCIETY ANNUAL GENERAL MEETING AND SEVENTH RESEARCH FORUM

The Fourth Annual General Meeting of the Hong Kong Meteorological Society will be held on Saturday 13th March, 1993. Further details of the meeting will be announced via regular newsletters as they become available.

The Seventh Research Forum on the subject of *Acquisition and Application of Hydrological Data* will be held on Saturday 13th March, 1993 in conjunction with the Fourth Annual General Meeting of the Society. Further details will be announced via regular newsletters.

A NEW OCCASIONAL PAPER FROM CUHK

The Department of Geography of the Chinese University of Hong Kong announced in September, 1992 the publication of a new occasional paper (# 115) by Ian Jackson and Steve S.I. Hsu entitled **Aspects of Rainfall and Water Balance of Hong Kong**. The following abstract was supplied with the notice.

An overview of a wide range of rainfall characteristics for timescales of less than a day to a year is presented. Work carried out by staff of the Royal Observatory, Hong Kong forms the basis of the review, one aim of the paper being to indicate the considerable number of important studies carried out there which may not be widely known. This earlier work is supplemented by analysis of more recent data. The overview allows the identification of future analysis to be undertaken by the authors of this paper. Since consideration of rainfall alone does not entirely indicate key aspects of the water situation in Hong Kong, a series of 11 different water balance models have been applied to rainfall and evaporation data using the pentad as the basic time unit. Periods and amounts of surplus, deficit and when soil moisture levels reach 50 percent of capacity are indicated. Variations in these parameters depending on the model assumptions adopted are indicated and this is important given the extremely varied nature of the land surface of Hong Kong. The excellence of the raingauge network is stressed and its potential not only for examining rainfall in Hong Kong but also in contributing to studies of tropical rainfall in a more general sense is indicated.

Comparisons of results of earlier and analyses of the most recent data highlight the differences found when different periods of records are used. This indicates the problems involved in using analyses of past data to estimate future conditions.

Amongst future analyses needed are those of a range of variability and probability characteristics for a variety of rainfall variables and also water balance studies. This may include investigation of possible fluctuations and correlations between rainfall variables and other meteorological parameters. All such analyses of variability may contribute to improved future prediction. Magnitudes of spatial variations of rainfall, including any differences in patterns of variability, are worthy of study. This may involve analyses of the factors responsible for such variations. Modelling of rainfall, particularly daily values, wet and dry spell characteristics, start and finish of wet and dry seasons and taking dependence into account is also considered worthwhile. Analyses of droughts, using definitions appropriate to tropical conditions rather than those of temperate latitudes and considering water supply-demand characteristics rather than only rainfall variables are also important. Water balance studies specific to certain environmental situations in Hong Kong are also warranted.

A NEW PERIODICAL FROM WORLD METEOROLOGICAL ORGANIZATION (WMO)

The World Meteorological Organization (WMO) has published the first issue of a new free periodical entitled ***World Climate News*** aimed at disseminating information about the global climate system and the major scientific and technical programmes of WMO. Anyone wishing to receive future issues of ***World Climate News*** should write, giving their full name and postal address to: The Secretary-General, World Meteorological Organization, Case postale 2300, CH-1211 Geneva 2, Switzerland.

A PERIODICAL FROM THE NETHERLANDS ON GLOBAL CHANGE

CHANGE, The Research and Policy Newsletter on Global Change from the Netherlands, is a quarterly publication on scientific research and policy making in the Netherlands concerning global change. It also informs about important international research and policy developments and aims at contributing to the international exchange of information and to promoting cooperation between those involved or interested in research and policy making on global change.

Recent articles of interest to HKMetS members include the following: Impacts of climate change on ecosystems and species: report from an international symposium; Effects of UV-B on resistance to infectious diseases; Satellite observation of the earth's environment and climate; the Dutch policy in the coming years; Global *Emiliana* modelling initiative (GEM), an international programme to study the role of life in the global climate; Reactions of trees and forests to climate change; Land ice and sea level; Exchange of CO_2 between the oceans and the atmosphere; Emissions data base for global atmospheric research - EDGAR; ESCAPE: an integrated climate model for the EC; Oceans and climate; Satellite altimetry: its use for monitoring the ocean; and Agriculture and the greenhouse effect.

CHANGE is published for Secretariate of the Netherlands' National Research Programme on Global Air Pollution and Climate Change by Kluwer Academic Publishers. To obtain a free subscription interested persons should write to: Kluwer Academic Publishers, Biosciences Division, P.O. Box 17, 3300 AA Dordrecht, The Netherlands (tel: (31) 78 334233; fax (31) 78 334254.

TWO PERIODICALS FROM CANADA ON GLOBAL CHANGE

DELTA, named after the fourth letter of the Greek alphabet, a universal symbol for incremental change, is a quarterly publication dealing with the Canadian Global Change Program (CGBP), the national focal point for global change activity in Canada. The CGBP represents a multidisciplinary network for coordinating research and communicating results, ideas and recommendations to the policy community.

The newsletter is available by email via Internet by contacting wcsrsc@carleton.ca. Those wishing to obtain hard-copy should write to: Canadian Global Change Program, Royal Society of Canada, P.O. Box 9734, Ottawa, ON, Canada, K1G 5J4.

Climate Adaptation News is the Newsletter of the Climate Adaptation Network, Canadian Climate Centre, Atmospheric Environment Service, Environment Canada. The first issue was released via email in October, 1992 introducing the objectives of the Climate Action Network and news items of some activities already taking place.

The newsletter is available by email via web:climate.news and EcoNet. To obtain hard-copy you should write to Canadian Climate Centre, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, ON, Canada, M3H 5T4 (tel: (1) 416 739 4330/4438).

CALL FOR PAPERS

First International Conference on Computer-aided Learning (CAL) and Distance Learning in Meteorology, Hydrology, and Oceanography (CALMet) , July 5-9, 1993, Boulder, CO, USA

The First International Conference on computer-aided Learning (CAL) and Distance Learning in Meteorology, Hydrology, and Oceanography (CALMet), sponsored by the World Meteorological Organization and the American Meteorological Society will be hosted by UCARUs Cooperative Program for Operational Meteorology, Education and Training (COMET) and will be held in Boulder, CO, USA from July 5th to 9th, 1993.

The theme for this first conference is "Getting it Right". The aim is to bring together meteorologists, educators, administrators, instructional technologists, and others who have an interest in the application of distance learning and computer-based learning technologies. This will be the first conference of its kind and will seek to stimulate ongoing and future activities which will benefit the international meteorological, hydrologic, and oceanographic communities.

The conference will consist of workshops, formal presentations, and displays of hardware and software by a variety of commercial vendors. The first two days will offer a series of workshops led by experts in their subject area. Workshops currently planned are: The Fundamentals of CAL and Multimedia; Using Effective Instructional Designs in CAL; Taking the Myth out of Authoring Systems; and Evaluating CAL Projects. The remaining three days will be devoted to the presentation of papers from invited speakers and submitted papers which will include development and assessment techniques as well as examples of the use of computer technology in education and training. Sessions will focus on these themes: steps needed to get into CAL; educational strategies and learning experiences appropriate for CAL; using CAL in operational settings; using CAL technologies in the traditional classroom setting; and others. All presentations will be given in English only.

Titles and abstracts (approximately one page, double-spaced) should include the author's name, affiliation, telephone/fax/email number. Abstracts should be submitted no later than 1 February, 1993 to the Conference Co-chairperson, Dr. Charles Duncan, Professor of Meteorology, University of Edinburgh, King's Buildings, Edinburgh EH9 3J2, United Kingdom (tel: (44) 31 650 5091; fax (44) 31 662 4269; email: C.Duncan@ed.ac.uk).. Authors of accepted papers are encouraged to submit a two page extended abstract for publication in a preprint volume. Deadline for submission of the extended abstract will be not later than 15 May, 1993. Instructions for the preprint volume will be mailed to authors in March.

For further information, interested persons are encouraged to contact either of the two Program Co-chairpersons: Charles Duncan (information above) or Brian Heckman, Manager, Distance Learning Program, Cooperative Program for Operational Meteorology, Education and Training (COMET), UCAR, Post Office Box 3000, Boulder, CO, USA (tel: (1) 303 497 8498; fax: (1) 303 497 8491; email: omnet b.heckman or heckman@comet.ucar.edu.

FORTHCOMING CONFERENCE

Third International Conference on School and Popular Meteorological and Oceanographic Education, July 14-18, 1993, Toronto, Canada

The Third International Conference on School and Popular Meteorological and Oceanographic Education will be held in Toronto (Canada) from July 14th to 18th, 1993. Like its predecessors, this conference will focus upon the roles of meteorology and physical oceanography in science education and the benefits to be gained from improving environmental awareness and literacy, particularly weather awareness, meteorological literacy and knowledge of the sea. It will also focus upon uses of modern technology in meteorological and oceanographic education, as well as ways and means of improving disaster preparedness in the less-developed countries of the world. The conference will be hosted by the Canadian Meteorological and Oceanographic Society and will also be sponsored by the Royal Meteorological Society and the American Meteorological Society.

The conference is intended for all who are interested in school and popular meteorological and oceanographic education, be they teachers, educationists, publishers, amateur observers, professional scientists, equipment manufacturers, journalists, weather hobbyists, or whatever.

The format of the conference will be mixed, with poster displays, oral presentations of papers and *hands-on* demonstrations of equipment and teaching aids. In addition, there will be an exhibition of books, videotapes, computer software and other resources for teachers.

JCUMetSat RECEIVING SYSTEM

In a paper by Kyle (1993, *this issue*) weather satellite images are used to illustrate tropical cyclones at various points in time. These images were received by the JCUMetSat Weather Satellite Receiving System which is available from James Cook University of North Queensland, Australia. The system is designed to receive low resolution data from the GMS series of Geostationary weather satellites operated by the National Space Development Agency of Japan and the Japan Meteorological Agency which orbit 35,700 km above the equator at a longitude of 140°E. Visible and infrared raw data from the satellite is transmitted to the Japan Meteorological Agency where it is fed into a computer which reformats it before transmitting it back to the satellite for re-broadcast. For low resolution data the full earth disk is split into four overlapping sectors, each of which is transmitted separately as an 800 line infra-red picture. The resolution is about 8 km for this data. Lines of latitude, longitude and country outlines are also included. The four sectors are transmitted once every three hours as analogue data.

The JCUMetSat Receiving System receives these analogue signals and converts them into digital signals for storage and display. To preserve the aspect ratio of the satellite data when displayed on a computer 752 samples per line are required. since a 16 level grey scale is used for the transmitted data the same is used for display. Various software provided with the system provides the necessary control for the hardware tracking, logging and pasting of transmitted data, and display of images. Pictures can be displayed either singly or as an animated sequence in black and white or in a false colour scheme. The displayed picture can also be printed by the software.

For those with access to Internet the images are regularly updated and stored in an archive at James Cook University from where they can be retrieved by anonymous ftp. The archive is held at the site marlin.jcu.edu.au [137.219.16.14] in the directory JCUMetSat.

For further details contact Prof. C.J. Kikkert, Department of Electrical and Computer Engineering, James Cook University of North Queensland, Townsville, Queensland, Australia, 4811. tel. +(61) 77-814259/814299; Fax +(61) 77-251348; email: eecjk@marlin.jcu.edu.au.

Reference:

Kyle, W.J. (1993) 1992 Tropical Cyclone Summary for the Western North Pacific Ocean (west of 180 degrees). *HKMetS Bulletin*, **3(1)**, 39-52.

Bill Kyle

Department of Geography & Geology

The University of Hong Kong

Hong Kong Weather Reviews

Climatological information employed in the compilation of this section is derived from published weather data of the Royal Observatory, Hong Kong and is used with the prior permission of the Director.

Review of summer 1992

Important climatological events

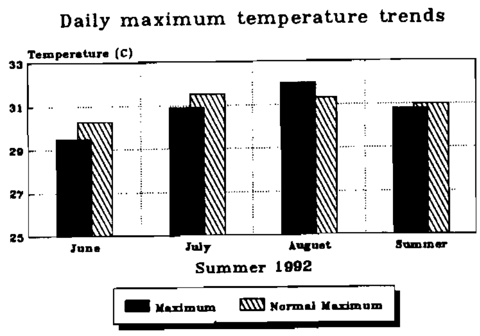
After the record wet Spring, Summer 1992 returned to near normal moisture levels with total rainfall 91 percent of the expected amount for the three month period. June was substantially wetter, and July slightly wetter than normal. However, August was unusually dry with only 25 percent of expected rainfall, the monthly total of 97.7 mm being the third lowest ever recorded. Nevertheless, with the large surplus in the first seven months of the year, the total rainfall at the end of the summer was still 47 percent above the January-August normal and the fourth highest on record for the period. The seasonal mean temperature was the same as the 1961-90 average but this also masked a marked change in August. Both June and July were cooler than normal. August, on the other hand, was unusually warm, the monthly mean of 29.4°C, and the mean daily minimum for the month of 27.3°C being second highest for August and the third highest for all months. The end of the extended wet spell after seven months of above-average precipitation coincided with both atmospheric and oceanic indices for August indicating a return to near-normal SST conditions in the tropical Pacific Ocean.

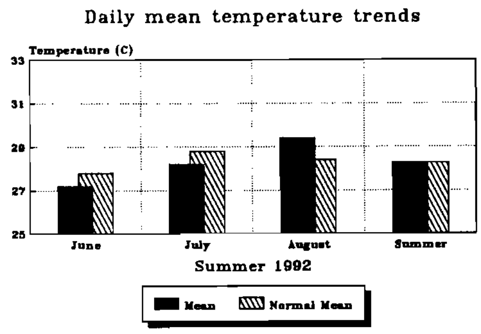
Mean daily temperature	**28.3°C**	**(0.0°C)**
Rainfall (provisional)	**988.6 mm**	**(91 %)**

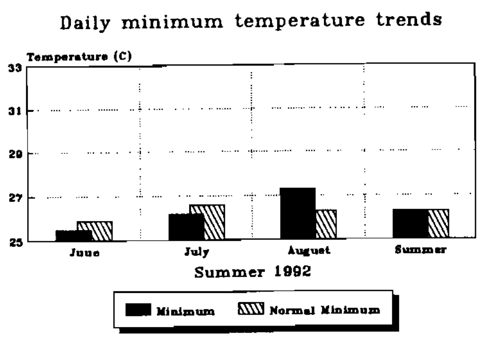
June

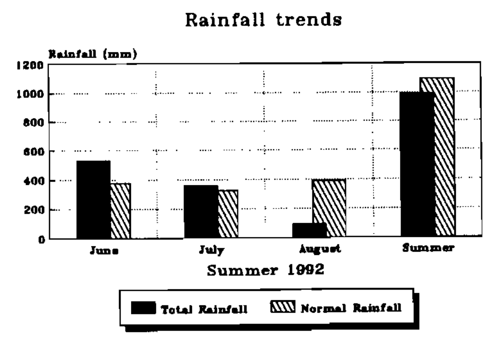
June 1992 was the sixth consecutive month with above-normal rainfall. The monthly total of 532.8 mm was 42 percent above the June normal. The persistent precipitation anomaly of the first six months of 1992 resulted in a record breaking 2,052.5 mm of rain, more than double the 1961-90 normal of 992.5 mm and some 150 mm more than the previous record set over 100 years ago in 1889. The persistence of cloudy, humid and rainy weather during the month also meant that temperatures were considerably lower than normal.

The first two days of the month were mainly fine and warm as a result of a fresh easterly airstream. As this subsided and was replaced by a moist maritime flow, cloudy conditions returned with light rain and coastal mist on 3rd. Nevertheless, apart from a few light showers, the next few days were fine and hot. Late on 5th an active southwest monsoon became established bringing morning showers and thunderstorms on 6th. Monsoon activity intensified with the approach of a trough of low pressure from the north giving heavy rain and squally thunderstorms on 7th, the heaviest downpours occurring in late morning over the central part of the New Territories. The passage of this trough was followed by a long spell of cloudy and rainy weather as the trough remained over the coastal waters of Guangdong. Under these dull, rainy conditions the month's low temperature of 22.5°C was recorded on 8th. Less frequent rain and more sunshine appeared on 12th but the improvement was brief. More unsettled weather returned on 13th as a result of the convergence, near Hong Kong, of the Pacific southeasterlies and the southwest monsoon. As rain clouds developed over the Pearl River estuary squally thunderstorms brought rainfall in









excess of 200 mm to some western parts of the territory. Over the next few days this battle of airstreams continued. On 14th, sunny intervals prevailed in the morning only for rain and thunderstorms to return in the afternoon. Air stream convergence became more pronounced again on the afternoon of 15th with most of the heavy rain falling in the central New Territories. The southwest monsoon returned and prevailed from 16th to 18th giving mainly fine weather apart from some morning showers and isolated thunderstorms. Another trough passed over the coast late on 18th, winds gradually turned easterly on 19th and became fresh on 20th bringing outbreaks of squally thunderstorms accompanied by heavy rain. This time the eastern part of the territory received around 150 mm during the two-day period. A marked change took place between 21st and 27th with mainly sunny and hot weather apart from a few morning showers. The hottest day recorded to date in 1992, 32.8°C on 25th, occurred during this time. Although the early part of the period was under the influence of the southwest monsoon the later part was dominated by the passage of tropical cyclone Chuck which gradually intensified as it traversed the northern part of the South China Sea from west of the Philippines towards Hainan. Winds intensified offshore on 26th and 27th and the outer rainbands of Chuck brought some heavy, squally showers on 28th. Winds moderated on 29th and turned southwesterly on 30th as showers died out and fine weather returned to end the month.

Mean daily temperature 27.2°C (-0.6°C)
Rainfall (provisional) 532.8 mm (142 %)

July

The monthly rainfall of July, although only 11 percent above average, meant that it was the seventh consecutive month of above average precipitation, and resulted in a January-July record total of 2,410.6 mm, nearly 200 mm above the annual average, and 83 percent above the normal of 1,316.0 mm for the same seven month period. Active southwest monsoon dominated the early part of the month and was followed by three tropical cyclone passages giving windier than normal conditions. Tropical Storm Faye on 18th also brought the ninth highest July daily rainfall of 177.7 mm. As was the case for June, temperatures were lower than normal although cloudiness and humidity were near normal.

The month started fine and warm but the southwest monsoon increased in strength progressively over the next six days giving gusty conditions. Morning showers during this period were light and brief. Cloudier conditions set in on 4th and the winds strengthened during the following two days as a trough developed over south China and moved southwards towards the coast. The southwest monsoon became more active on 6th as the trough approached giving strong winds and an intense outbreak of rain and thunderstorms in the evening. At the Royal Observatory temperatures dropped by more than 4 degrees in one hour as the rain started. The next day saw the lowest recorded temperature for the month, 23.4 °C, as fresh to strong winds marked the crossing of the coast by the trough. Winds then turned northerly and subsided rapidly that evening. Clouds and intermittent rain marked 8th as the trough gradually dissipated offshore. Sunny periods returned on 9th and, apart from some thundery showers in the early hours, remained fine on 10th. Over the following twelve days weather was influenced by the passage, across the northern part of the South China Sea, of three tropical cyclones. Typhoon Eli entered the South China Sea from central Luzon on 11th and made landfall on Hainan two days later. Eli's outer rainbands brought squally showers on 12th and 13th but the amount was small, around 40 mm, and there were fairly long periods of sunshine during the two days. The next three days were generally fine and dry. Faye developed on 17th over the northern part of the South China Sea and intensified to a Tropical Storm as it moved towards the Pearl River estuary. Rain started on 17th and winds freshened from east to northeast during the day, turning to southerly and increasing in strength during the night. Early on 18th intense rainbands near the centre of Faye brought heavy rain and squally thunderstorms. Over the western New Territories over 300 mm of rain fell and extensive flooding occurred. Stormy conditions continued for most of the day but died out rapidly by evening. A brief respite on 19th with generally fine weather was brought to an end by the entry of Gary into the South China Sea on 20th after crossing Luzon as a tropical depression. By the night of 21st Gary had moved northwards and intensified into a severe tropical storm. The first outer rainbands reached the territory on the afternoon of 21st though subsequent rainbands did not affect us until the evening of 22nd. During this time easterly winds strengthened significantly and gales affected the territory early on 22nd. Winds moderated gradually later that day but cloudy conditions with intermittent light rain continued on 23rd. A fine spell began on 24th and was maintained till the end of the month with only brief passing showers. The month's highest temperature, 32.4°C, was recorded on 28th and again on 31st, during this week-long spell of hot, sunny weather.

Mean daily temperature	**28.2°C**	**(-0.6°C)**
Rainfall (provisional)	**358.1 mm**	**(111 %)**

August

August was in sharp contrast to the first seven months of the year in being one of the driest and hottest on record. The total monthly rainfall was just 25 percent of the normal of 391.4 mm, the driest August since 1962. Both the monthly rainfall of 97.7 mm and relative humidity of 77 percent were third lowest ever recorded. The mean daily maximum temperature of 32.0°C was the fifth highest recorded for the month. Both the monthly mean temperature of 29.4°C and the mean daily minimum temperature for the month ranked second highest for August and third highest for all months. The hot dry weather in the early part of the month was associated with moderate southwesterlies whereas the prolonged presence of two tropical cyclones in the latter half induced spells of northwesterly flow from hot, dry inland regions to the coast of Guangdong.

The month began with the continuation of the fine weather at the end of July. Other than a few morning showers on 1st the first eight days were hot and sunny with light to moderate southwesterly winds. The wind shifted to east to southeasterly towards the evening of 8th producing some thundery showers and giving the lowest temperature recorded during the month of 25.6°C. Over the next week showery weather brought by scattered rain clouds from the South China Sea in the moderate southeasterly flow prevailed although on 10th there was a brief strengthening of the easterlies. Another change took place on 16th as Hong Kong started to be affected by Tropical Storm Mark which began as a tropical depression about 400 km east-southeast of the territory that morning. During the first four days when Mark developed and drifted slowly northwards over the coastal waters of eastern Guangdong moderate north to northwesterly winds brought mainly fine and hot weather. Mark made landfall near Shantou on the morning of 19th and turned south-southeastwards and weakened rapidly as it moved out to sea and drifted westwards towards Hong Kong. The weather became cloudy on 20th as the remnant passed just south of Hong Kong. Afterwards winds turned easterly and freshened giving strong winds offshore and periods of rain. Although the winds subsided the following morning, cloudy and showery weather continued for the next few days until fine weather returned on 25th for two more days. Tropical Depression Polly neared Taiwan on 27th marking another change as Hong Kong became affected by its extensive circulation giving another period of northwesterly flow which persisted till the end of the month. During this time days were hot and sunny. Although the high temperatures generated intense heat thunderstorms on the evenings of 27th and 28th neither generated much rainfall. The hot, dry northwesterly flow continued producing one of the hottest days ever in Hong Kong on 30th. The daily mean temperature on that day, 32.0°C, beat the previous record set on 18 August 1990 by 0.1°C. The daily minimum temperature of 30.0°C was the second highest ever recorded for any month and the daily maximum temperature of 35.0°C was the fifth highest recorded in August.

Mean daily temperature	**29.4°C**	**(+1.0°C)**
Rainfall (provisional)	**97.7 mm**	**(25 %)**

Review of autumn 1992

Important climatological events

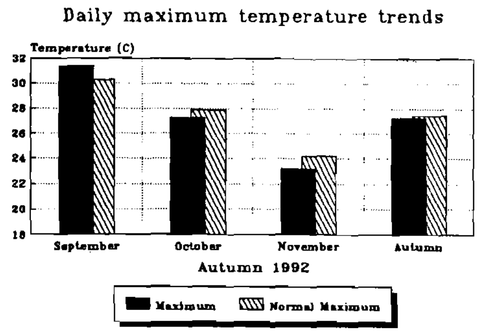
Autumn 1992 was climatologically near normal both with regard to temperature (0.1°C below normal) and rainfall (99 percent of normal). However, these figures obscure a significant change that took place during the season. September was generally warm and dry with the mean temperature of 28.1°C being the fourth highest on record for the month. Rainfall of 178.7 mm was only 60 percent of that normally expected. October, even though it had long hours of sunshine and below-normal humidity, was a very rainy month with 203 percent of the 1961-90 normal amount. It was also the first month since May 1990 when the mean temperature was below the 30-year normal. November, under the influence of a series of continental anticyclones, continued this cooler than normal trend. It was also very dry, with the total of 2.7 mm being only about 8 percent of the monthly normal of 35.1 mm.

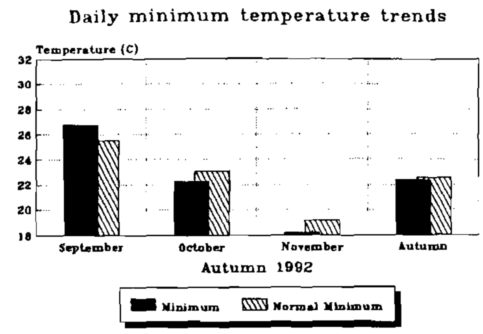
Mean daily temperature	**24.6°C**	**(-0.1°C)**
Rainfall (provisional)	**104.1 mm**	**(22 %)**

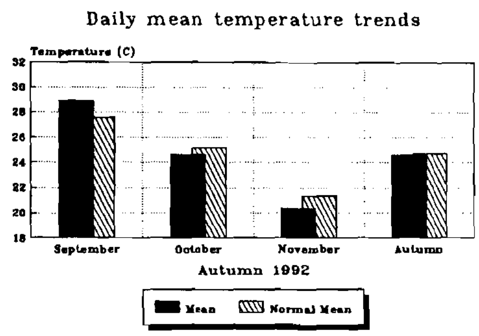
September

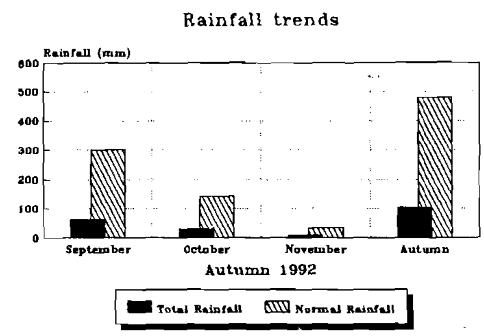
September, like August, was hot and sunny with relatively little rain. These warm, dry anomalies were again closely linked to the passage of tropical cyclones to the east of Taiwan. The mean air temperature of 28.9°C and the mean daily maximum temperature of 31.4°C were respectively the second and fifth highest on record for the month. The mean daily minimum temperature of 26.8 °C was, however, the highest ever recorded in September. The first day of the month, with a mean air temperature of 31.1°C and a mean minimum of 29.5°C may well be considered the hottest September day on record. Total rainfall of 63.1 mm was only 21 percent of the normal of 299.7 mm. In fact, most of the monthly total was associated with the passage of Typhoon Omar across Guangdong to the north of Hong Kong.

The first few days were fine and hot as the northwesterly flow associated with Severe Tropical Storm Polly continued to bring hot, dry air to the coastal regions. As Polly moved away Typhoon Omar approached Taiwan and the same flow pattern persisted leading to the month's maximum temperature of 33.5°C on 4th. Clouds increased on 5th as Omar crossed Taiwan but it remained hot during the day before the spell broke with thunderstorms in the evening. Overnight westerly flow freshened and rain became frequent as the remnant of Omar passed to the north of Hong Kong. On 6th winds turned southeasterly but stayed fresh and gusty. Heaviest rain occurred over the New Territories with 120 mm in Yuen Long on the morning of 7th. Winds moderated but light rain persisted till near noon on 8th. The next eight days were predominantly fine and dry apart from a few showers although cloudy periods and light rain occurred late on 10th when an easterly airstream arrived. Cloudy weather returned on 16th as air flows converged near Hong Kong generating thunderstorms near noon and midnight. The easterlies prevailed bringing a mixture of sunshine and clouds over the next three days. As an area of low developed over Xisha strong easterlies blew offshore on 18th and 19th before subsiding on 20th heralding the return of hot, sunny weather. Hong Kong was then affected by the outer circulation of Severe Tropical Storm Ted and on 21st the maximum temperature again reached the month's high of 33.5°C. As Ted tracked northwards across eastern China local winds turned westerly and then easterly on 24th. The first surge of the northeast monsoon arrived in the form of fresh easterlies on 26th lowering the daytime maximum temperatures by five degrees between 25th and









27th. Some light rain patches also occurred from time to time, most frequently on the evening of 26th and the morning of 27th. A weak northeast replenishment on 29th brought somewhat cloudier conditions but generally fine and hot weather persisted to the end of the month.

Mean daily temperature	**28.9°C**	**(+1.3°C)**
Rainfall (provisional)	**63.1 mm**	**(21 %)**

October

The dominant circulation pattern in October was that of the northeast monsoon as indicated by the monthly mean pressure of 1015.6 hPa, the eighth highest on record for the month. Under the influence of the prevailing continental air mass temperatures were, in general, below normal and the monthly mean relative humidity of 66 percent was the seventh lowest on record. However, just before the onset of the first surge, in the early hours of 4th, the fifth highest daily minimum for October of 27.0°C was set. The month was also very dry with total rainfall of 30.9 mm only 21 percent of the October normal of 144.8 mm.

The month started with a moist southeasterly airstream producing some local showers in the morning of 1st but this soon gave way to hot, sunny weather over the next few days leading to the month's high of 31.2 °C on 3rd. This warm spell continued until the arrival, early on 5th, of a surge of the northeast monsoon. The passage of the cold front across the south China coast was marked by a freshening of northerly winds, increased cloud and rain and a temperature drop of two to three degrees. Winds changed to easterly on 6th and persisted until 12th bringing light rain on four consecutive nights from the 6th. However, weather remained fine during the day. A replenishment from the north arrived on 13th bringing a slight lowering of temperature, increased cloud and some light rain patches early that day. The dry, continental air cleared the clouds on 14th and lowered relative humidity below 60 percent where it remained for the next five days by which time winds had turned easterly and freshened. Apart from the active northeast monsoon, persistent windy conditions, particularly offshore, during this period may be attributed to enhancement associated with the slow passage of Severe Tropical Storm Angela across the central part of the South China Sea. Another northerly replenishment on 24th again lowered relative humidity and temperature. During the 13-day fine spell from 14th to 26th there was no rain but each replenishment lowered temperatures progressively to the minimum of 19.6°C on 26th, the lowest recorded for the month. Easterly winds became stronger on 27th as Severe Tropical Storm Colleen tracked across the South China Sea. Extensive outer cloud bands brought some rain to Hong Kong that night and the following morning. Winds then moderated on 29th and fine weather returned and remained till the end of the month.

Mean daily temperature	**24.6°C**	**(-0.6°C)**
Rainfall (provisional)	**30.9 mm**	**(21 %)**

November

November was also a month dominated by active northeast monsoon again evidenced by the second highest monthly mean pressure on record of 1020.1 HPa. The dominance of the continental anticyclone maintained a steady supply of cool, dry air giving sunny and clear skies leading to a mean cloud amount of 31 percent, the fourth lowest on record for the month. Total rainfall of 10.1 mm, only 29 percent of normal, occurred only on 3 days with most falling on 14th under the influence of an easterly airstream.

The month began with strong easterlies as the monsoon surge of late October continued giving fine weather for the first five days as the winds moderated. The month's high temperature of 26.4°C was reached on 5th as temperatures recovered. A renewed easterly flow on 7th did little to affect the fine, mild weather but the arrival of the first major surge of the winter on 8th marked a change in regime. The onset was preceded by light rain in the afternoon and temperatures began falling in the evening as winds strengthened from the north to become strong offshore the next morning. The cold surge reached its peak on 10th when the month's low temperature of 13.1°C was recorded at the Royal Observatory. That afternoon relative humidity also dropped to a low of 19 percent. Moderate winds and mild temperatures persisted until the weather deteriorated on 14th due to freshening easterlies and moisture brought by an upper-air flow which produced the major rain event of the month. The rain eased off on the morning of 15th and brighter conditions returned later that day. The remainder of the month was dry and was dominated by fine weather. Two burst of the winter monsoon during this time generated very dry conditions. The first arrived as a cold front on the morning of 20th with northerly winds increasing in strength that day. Temperatures dropped about 7°C from 19th to 21st and mean relative humidity dropped below 60 percent. A second replenishment arrived on 25th as northeasterlies strengthened and then veered easterly the following day. This had a weaker cooling effect with temperatures falling by 3 to 4 degrees but the drying effect was more markedas mean relative humidity dropped to 46 percent on 26th. This dry spell continued until the last day of the month when warmer maritime air began to affect the coastal areas.

Mean daily temperature	**20.4°C**	**(-1.0°C)**
Rainfall (provisional)	**10.1 mm**	**(29 %)**

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1992 Tropical Cyclone Summary for the Western North Pacific Ocean (west of 180 degrees)

Information employed in the compilation of this section is derived from warnings and other published material issued by U.S. National Hurricane Center, Miami; U.S. Central Pacific Hurricane Center, Hawaii; U.S. Naval Western Oceanography Center, Hawaii; U.S. Joint Typhoon Warning Center, Guam; Japanese Meteorological Agency, Tokyo; Philippine Meteorological Service, Manila; and Royal Observatory, Hong Kong.

*Storms marked *, **, ***, **** caused the #1, #3, #8, or #9/10 Tropical Cyclone Signal respectively to be hoisted in Hong Kong. Track maps, courtesy of the Royal Observatory, are provided for these storms.*

Keywords:

Tropical Cyclone, Tropical Depression, Tropical Storm, Hurricane, Typhoon

Typhoon Axel (9201)

The first tropical depression of 1992, 01W, formed near 5N 178E, about 3,000 km east of Truk, on 5 January and moved slowly west-northwest toward the Marshall Islands with 55 km h^{-1} winds. It continued westward at about 20 km h^{-1} as it intensified into Tropical Storm Axel about 2,700 km east of Truk on 6 January and Typhoon Axel about 1,750 km east of Truk on 7 January. This intensity was based on several ship and land station reports in the Marshall Islands. Axel turned west-northwest and accelerated to 27 km h^{-1} on 9 January reaching peak intensity of 150 km h^{-1} that day before weakening to a tropical storm later. It continued to weaken on 10 January, then it resumed a westward course with 65 km h^{-1} winds on 11 January while in the Caroline Islands. Passing 430 km south of Guam early on 13 January Axel turned north-northwest and weakened to a tropical depression about 500 km west of Guam the next day. Axel turned north on 14 January and then accelerated north-eastwards on 15 January, becoming extratropical later that day near 20N 143E, some 1,100 km north-northeast of Guam. While Axel passed through the Marshall and Caroline Islands during its lifetime, there are no reports of damage or casualties.

Tropical Storm Ekeka

Former Hurricane Ekeka entered the Western North Pacific Basin late on 3 February moving west. Ekeka started life near 5N 155W on 26 January. The system slowly developed and became Central North Pacific Basin Tropical Depression 01C near 5N 157W on 28 January. Moving in a westerly direction the depression became Tropical Storm Ekeka on 29 January. Hurricane intensity was reached the next day. On 31 January, Ekeka turned west-northwest while continuing to intensify. Ekeka was the first January hurricane of record in the Central North Pacific Basin. A maximum intensity of 185 km h^{-1} was reached early on 2 February. Thereafter, strong shearing conditions caused rapid weakening, and by the time Ekeka reached the Dateline late on 3 February it was a 85 km h^{-1} tropical storm. The storm continued a general westerly motion as it weakened to a depression east of Wotje in the Marshall Islands on 5 February. Ekeka turned west-southwest on 7 February and dissipated the next day near 7N 150E, in the Caroline Islands.

Typhoon Bobbie (9202)

Tropical Depression 02W formed near 10N 132E, about 1,300 km east-southeast of Manila, Philippines on 23 June. The system became Tropical Storm Bobbie later that same day when it was about 1,070 km east-southeast of Manila and moving in a north-northwest direction.

Bobbie turned northwesterly and moving at a speed of 20 km h^{-1} steadily intensified, reaching typhoon intensity on 25 June about 730 km east of Manila. The system continued on a northwest track through 26 June, then turned north that night and reached a peak intensity of 220 km h^{-1} east of Taiwan on 27 June. Bobbie recurved northeastward that evening about 420 km south-southeast of Taibei. It then weakened on 28 June as it moved east-northeast with 175 km h^{-1} winds through the Ryukyu Islands coming very close to the islands of Miyakojima, Ishigakijima, and Okinawa. At 0000 UTC 29 June, Okinawa reported 75 km h^{-1} sustained winds with gusts to 125 km h^{-1} and a pressure of 979 hPa as well as severe disruption to services. Bobbie continued an east-northeast course while gradually weakening to a severe tropical storm about 650 km east-northeast of Okinawa on the morning of 30 June. The storm became extra-tropical that night near 35N 141E, about 150 km southeast of Tokyo, Japan.

**Typhoon Chuck (9203)*

An area of disturbed weather over the western North Pacific Ocean weakened as it traversed the Philippines on 23 June. After entering the South China Sea it re-organized to form Tropical Depression 03W, near 13N 119E, about 300 km southwest of Manila, Philippines on 24 June. Moving erratically at 18 km h^{-1} west-northwest, the system reached tropical storm intensity the next day some 460 km southeast of Xisha and reduced its forward speed to 8 km h^{-1}. That night Chuck intensified to a severe tropical storm about 360 km southeast of Xisha. The storm continued west-northwest on 26 June and then turned northwestward on the morning of 27 June as it reached typhoon intensity near Xisha, where during the closest approach, a pressure of 966 hPa was recorded. The Stand By Signal #1 was hoisted at 0850 HKT that morning when Chuck was 690 km south-southwest of Hong Kong. A peak intensity of 130 km h^{-1} was reached later in the day and the Strong Wind Signal #3 was raised at 2050 HKT as local winds increased. Chuck was closest to Hong Kong, about 600 km to the southwest, at 0200 HKT on 28 June. Turning gradually west-northwestward Chuck crossed the south-western part of Hainan Dao on the morning of 28 June and weakened to tropical storm intensity in the process. All signals were lowered in Hong Kong at 1400 HKT that day. Yaxian, in southern Hainan Dao, reported a pressure of 964 hPa as Chuck passed 40 km to the north-northeast. Chuck then moved northwest at 13 km h^{-1} across the Gulf of Tonkin (Beibu Wan) toward Vietnam with 85 km h^{-1} winds. As it crossed the Gulf it re-intensified and made landfall in northern Vietnam about 100 km east of Hanoi on 29 June with winds of 110 - 120 km h^{-1}. Chuck continued inland and dissipated over northern Vietnam about 200 km north-northwest of Hanoi the next day. In Hainan one person was reported killed and 19 injured and considerable economic loss sustained. A storm surge was also reported along the coastal areas of Guangxi where one death and extensive loss due to flooding was reported. Press reports also indicate that 21 people were killed and 87 were missing in the Vietnamese coastal areas where Chuck made landfall. Considerable damage to property has also been reported. The track of Typhoon Chuck is shown in Figure 1.

Tropical Storm Deanna (9204)

Tropical Depression 04W formed near 7N 143W, on 26 June. It moved in a west to west-southwest direction through 27 June, then started a slow westward drift east of the Philippines with 55 km h^{-1} winds. It turned northwest at 22 km h^{-1} on 29 June and continued this motion through 1 July. The system slowly strengthened and reached tropical storm intensity that day. Deanna recurved northeast on the night of 2 July while reaching a peak intensity of 75 km h^{-1}. The storm accelerated to about 45 km h^{-1} towards the northeast the next morning while weakening to a depression about 700 km east-northeast of Okinawa. The system became extratropical near 32N 137E on 4 July.

**Typhoon Eli (9205)*

Tropical Depression 05W formed near 13N 135E, about 500 km northwest of Yap, on 9 July. Moving west-northwestwards at about 30 km h^{-1} the system strengthened rapidly, reaching tropical storm intensity early on 10 July about 820 km west-northwest of Yap and severe tropical storm strength about 780 km east of Manila later that day. The storm then moved on a more westward track gaining typhoon intensity next morning some 200km northeast of Manila just before making landfall on Luzon. The storm crossed Luzon with 140 km h^{-1} winds on 11 July, with the system weakening temporarily to a severe tropical storm with 120 km h^{-1} winds due to the friction effect of the mountainous terrain. Passing Baguio on a west-northwest track a weaker Eli moved into the South China Sea as a severe tropical storm that afternoon, turned west at about 30 km h^{-1} that evening and then reverted to a west-northwest track the next day. Weather in Hong Kong was fine on 11 July ahead of the storm. The Stand By Signal #1 was hoisted at 2030 HKT when Eli was 760 km to the southeast. As Eli continued moving west-northwest across the

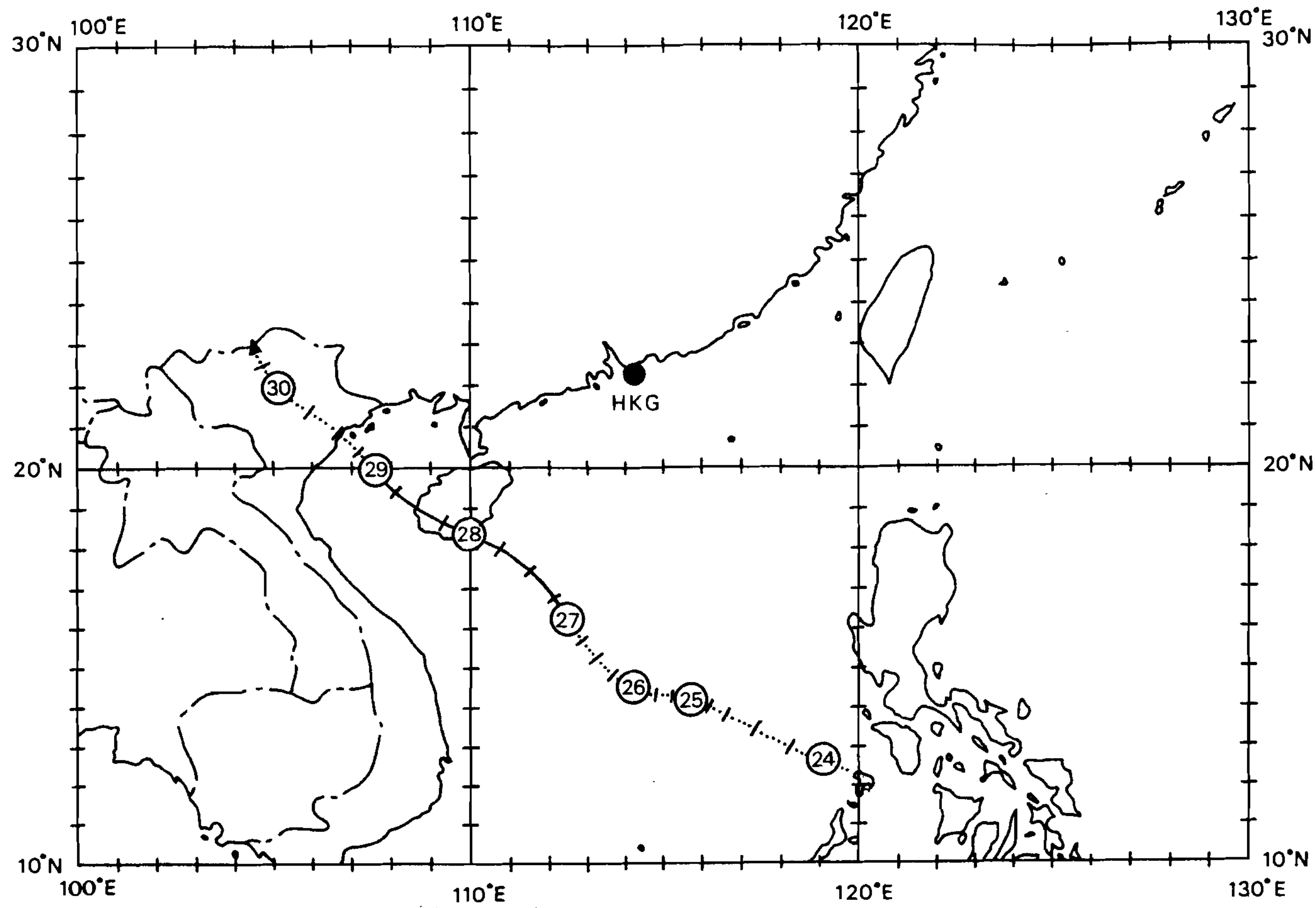

Figure 1 Track of Typhoon Chuck (9203), 24 - 30 June, 1992 (after Royal Observatory, Hong Kong)

South China Sea (at a slower forward speed than that observed before crossing Luzon) it came steadily closer to Hong Kong. The Strong Wind Signal #3 was raised at 1000 HKT on the morning of 12 July with Eli 580 km south of Hong Kong. The squally showers of the outer rainbands affected local areas that afternoon and winds strengthened overnight. Eli came closest to Hong Kong about 0500 HKT the next day when it was about 480 km to the southwest. All signals were lowered at 0945 on 13 July when the storm was 520 km southwest of Hong Kong and moving away on its west-northwest track. Eli briefly regained typhoon intensity around this time as it approached the east coast of Hainan Dao with 130 km h^{-1} winds. It crossed the coast about 100 km south-southeast of Haikou and passed over the northern part of Hainan Dao during the day. Weakening again to a severe tropical storm, it turned northwest across the Gulf of Tonkin (Beibu Wan) and moved into Vietnam about 150 km east of Hanoi that evening as a 110 km h^{-1} tropical storm. Eli then dissipated over Vietnam the next day, weakening rapidly to a tropical depression before degenerating into an area of low pressure near 22N 105E. Press reports indicate that four people died and 17 were missing due to Eli's passage across Luzon in the Philippines. The storm also caused widespread damage in northern Hainan and in Vietnam. In Hong Kong 23 people were injured in weather-related accidents. Figure 2 shows the track of Typhoon Eli.

**Tropical Storm Faye (9206)

Tropical Depression 06W originated from an area of low pressure to the east of Luzon near 17N 124E on 14 July. Moving west, it crossed northern Luzon later that day. The disturbance turned west-northwest without any signs of intensification as it drifted through the South China Sea on 16 July. During the night it turned north and became a tropical depression about 250 km south of Hong Kong around 0000 UTC on 17 July. Stand By Signal #1 was then raised at 0900 HKT when Faye was 230 km south of the Territory. Faye moved generally northwards at 12 km h^{-1} towards the Pearl River estuary and reached tropical storm intensity about 120 km southwest of Hong Kong that evening. During this time winds freshened and the Strong Wind Signal #3 was hoisted with the storm about 100 km to the southwest and continuing to intensify and drift closer to the coast. Winds turned to the south and strengthened overnight and conditions

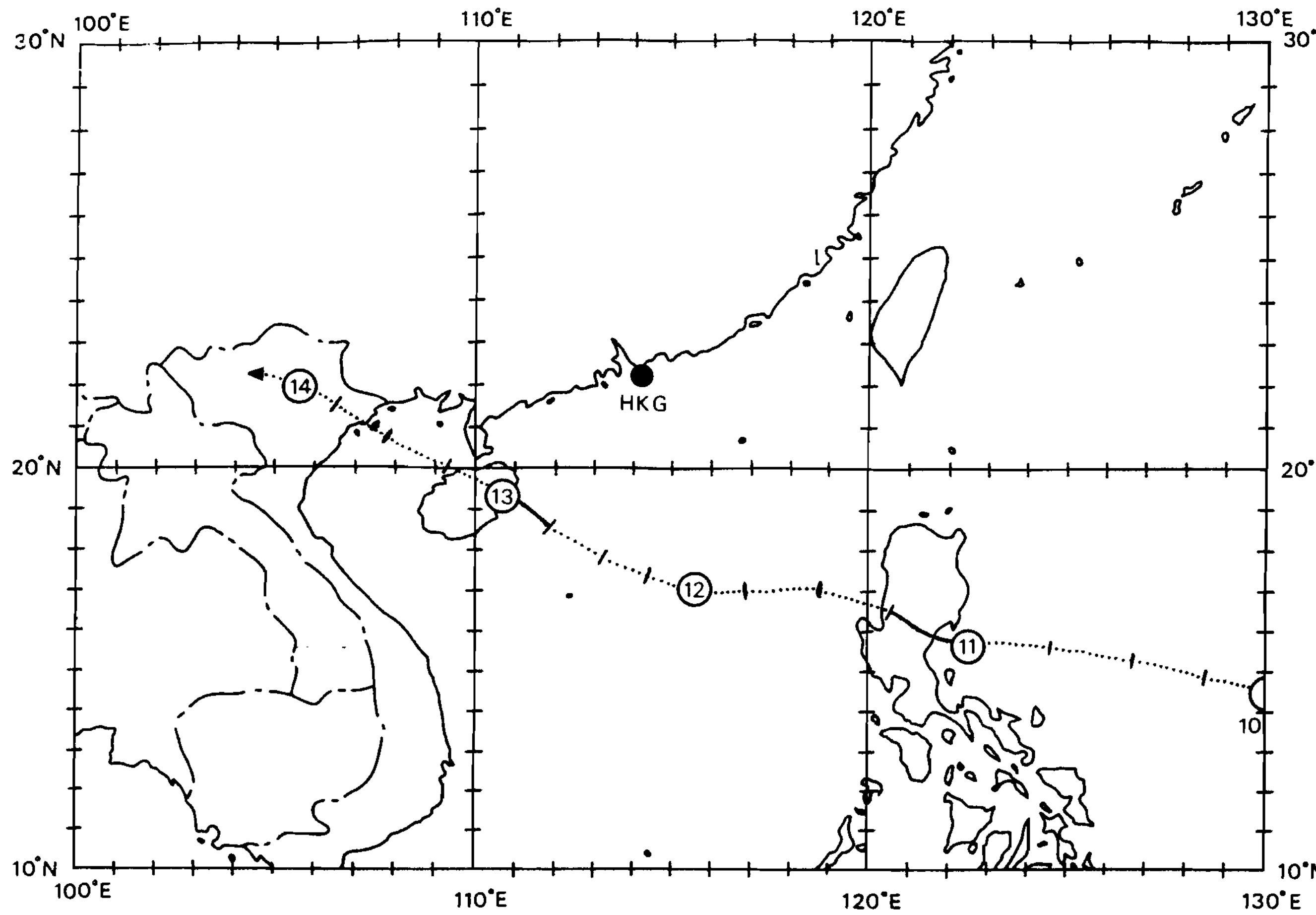

Figure 2 Track of Typhoon Eli (9205), 9 - 14 July, 1992 (after Royal Observatory, Hong Kong)

in Hong Kong deteriorated as Faye moved into the Pearl River estuary. The storm reached a maximum intensity of 85 km h^{-1} just as it passed east of Macau about 0000 UTC on 18 July. Lowest pressure of 1003.6 hPa was recorded at the Royal Observatory at 0600 and 0700 HKT. Torrential rain and severe squalls occurred as Faye made landfall 50 km northwest of Hong Kong around 0900 HKT, it closest approach. These persisted for most of the day as Faye turned northeast and dissipated over southern China about 150 km north-northeast of Hong Kong that evening. After landfall, winds over Hong Kong subsided quickly and all signals were lowered at 1605 HKT when the remnant of Faye was about 100 km to the north. Two people were killed and eleven injured during Faye's passage. Although the storm had a short life span it produced one of the most severe rainstorms seen during passage of tropical cyclones resulting in serious flooding and many landslips. The track of Faye is plotted in Figure 3.

***Typhoon Gary (9207)

Tropical Depression 07W formed on 19 July near 15N 130E, about 1,030 km east of Manila. The system moved in a general west-northwesterly direction, approaching Luzon in the Philippines with 55 km h^{-1} winds on the morning of 20 July. The system crossed Luzon on that day reaching tropical storm intensity soon after emerging into the South China Sea that evening and proceeded on a more westerly track. In Hong Kong the Stand By Signal #1 was raised at 2230 HKT on 20 July when Gary was 770 km to the southeast. The storm turned west-northwest on 21 July heading towards the Guangdong coast to the west of Hong Kong. Winds strengthened gradually from the northeast during the day as Gary came closer and the Strong Wind Signal #3 was hoisted at 1545 HKT with the storm 470 km south-southeast of Hong Kong. Later that evening, when Gary was about 310 km south of Hong Kong it intensified into a Severe Tropical Storm and swung to a more westerly track during the night. The Gale or Storm Signal #8NE was hoisted at 0545 HKT on 22 July when Gary was 290 km to the south just shortly before its closest approach estimated to be at 0700 HKT. As Gary moved away it started to move on a more westerly track and the Gale or Storm Signal #8SE replaced #8NE at 1100 HKT when the storm moved into the SW quadrant. Typhoon intensity was reached for a brief time just east of Hainan Dao in the early afternoon when peak winds of

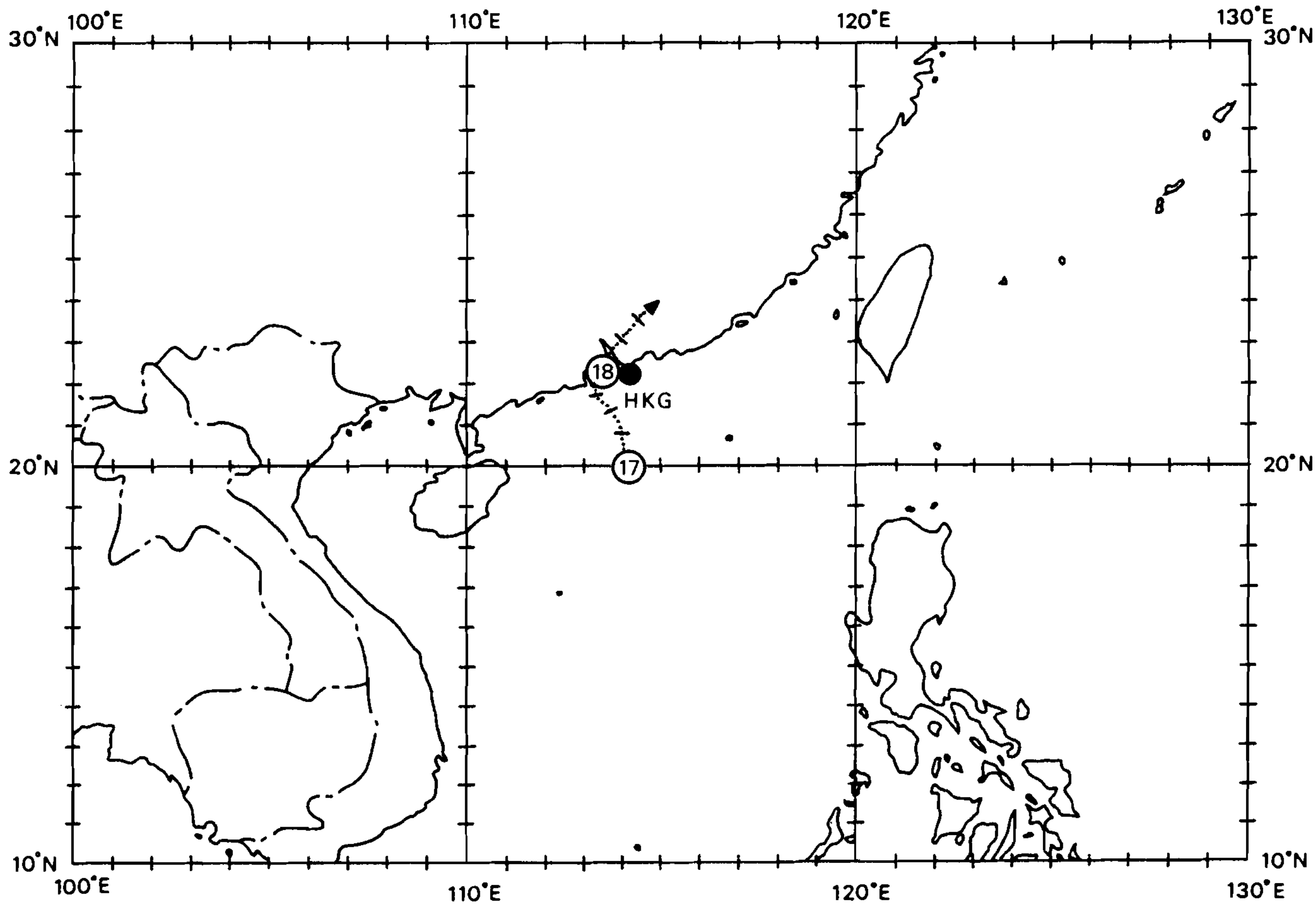

Figure 3 Track of Tropical Storm Faye (9206), 17 - 18 July, 1992 (after Royal Observatory, Hong Kong)

120 km h^{-1} were reached. As it approached northeast Hainan Dao Gary turned more northwestwards and landed about 20 km southwest of Zhangjiang on Leizhou Peninsula during the night. The Gale or Storm Signal #8SE was replaced by Strong Wind signal #3 when Gary was 330 km to the southwest at 1615 HKT and all signals were lowered at 1850 HKT as local winds subsided and the system no longer posed a threat. After landfall Gary moved into southern Guangxi on 23 July and dissipated over land later that same day, degenerating into a tropical depression about 190 km west of Nanning and an area of low pressure overnight. Press reports indicate that 11 people were killed and 3 missing in the Philippines due to Gary. Extensive damage was also caused in southwestern Guangdong and Guangxi with gales and torrential rains disrupting communications, electricity and water supplies, and destroying many homes and large areas of farmland. One person was reported killed and nine others injured in Guangdong and in Guangxi 25 people were killed and 54 injured. In Hong Kong there were reports of 18 people being injured by falling objects during the passage of Gary. The track of Typhoon Gary, the first storm of 1992 requiring the hoisting of the #8 signal in Hong Kong, is shown in Figure 4.

Tropical Storm Helen (9208)

Tropical Depression 08W formed very rapidly near 25N 158E (close to Minamitorisima or Marcus Island and about 1,700 km east of Iwo Jima) early on 26 July. It apparently formed from the surface reflection of an upper level low pressure system. Moving northwards at 14 km h^{-1}, it intensified to a tropical storm that afternoon. The system reached a peak intensity of 85 km h^{-1} later that same day. Helen then turned north-northeast and accelerated to a speed of 38 km h^{-1}. The system then moved generally northeast during 27-28 July as it slowly weakened to a tropical depression on the morning of 28 July about 1,880 km east of Tokyo and then to a low pressure system later that same day near 36N 151E. While this was the end of Helen as a tropical cyclone, the remnant low was trackable for a day longer as it moved northeast.

Tropical Storm Irving (9209)

Tropical Depression 09W formed on the afternoon of 31 July near 20N 131E, about 790 km south-southeast of Okinawa and began drifting westward at about 14 km h^{-1}. The system

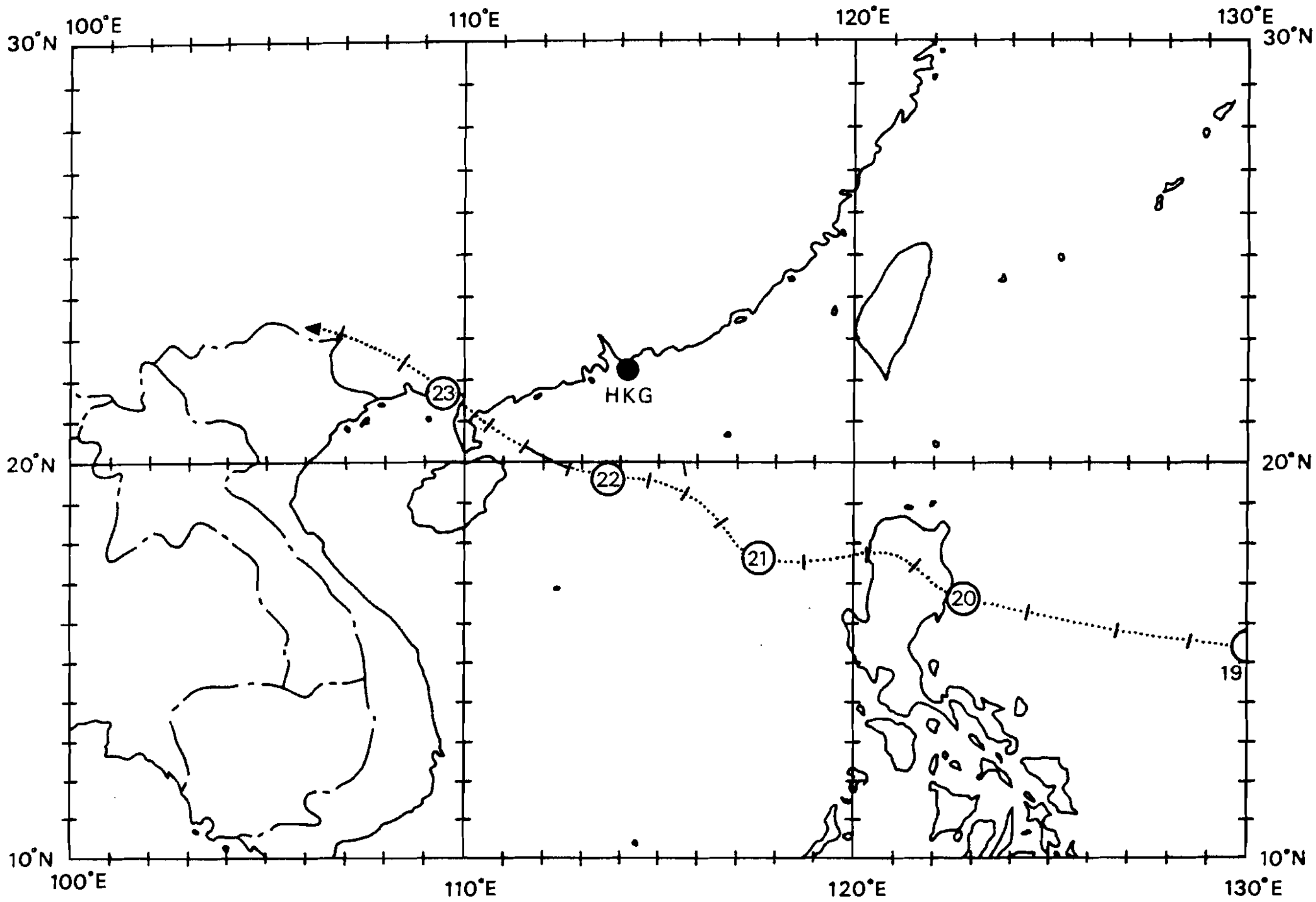

Figure 4 Track of Typhoon Gary (9207), 19 - 23 July, 1992 (after Royal Observatory, Hong Kong)

drifted very erractically northward through 1 August, with some of the erratic motion being due to the poor definition of the centre. On 2 August, the system reached tropical storm intensity about 370 km east of Okinawa and started a northward motion east of the Ryukyu Islands with 75 km h^{-1} winds. Irving moved north to north-northeast toward Japan while strengthening to 100 km h^{-1} on 3 August. This turned out to be the peak intensity. Irving turned north-northwestwards and crossed Shikoku and Kyushu in southern Japan on 4 August as it took a sharp turn to the west. The storm weakened to a tropical storm while over Kyushu. This occurred very rapidly due to the combined effects of landfall and shearing, and by the morning of the next day it had weakened to a depression over the Strait of Korea. Irving dissipated on 5 August over the southwestern part of South Korea about 140 km west of Pusan. The major impact of Irving was heavy rain over Kyushu which interrupted transport services.

Typhoon Janis (9210)

Tropical Depression 10W formed near 12N 145E, about 220 km south of Guam, on 3 August. Moving northwest at a speed of 27 km h^{-1} the system became Tropical Storm Janis later that day after passing near Guam. Janis moved in a generally northwest direction through 6 August as it strengthened. Typhoon intensity was reached about 1,200 km southeast of Okinawa on 5 August, and a peak intensity of 230 km h^{-1} was reached on 6 August. Janis recurved to the north-northeast on 7 August as it moved through the Ryukyu Islands. Reports indicate Okinawa received peak gusts of 90-110 km h^{-1}, with a mimimum pressure of 994 hPa at Kadena Air Base as Janis passed to the east. Higher winds undoubtedly affected other islands. Janis made landfall on Kyushu, Japan on 8 August with 165 km h^{-1} winds. The system turned northeast over Japan and weakened to a severe tropical storm over western Honshu later that same day. Continuing northeastwards Janis weakened further to a tropical storm over northern Honshu and became extratropical over Hokkaido the next day.

Typhoon Kent (9211)

Tropical Depression 11W formed over the Marshall Islands on 5 August near 10N 169E, about 1,100 km south-southeast of Wake. Moving generally northwestward, the system attained tropical storm intensity the next day. Kent maintained a northwesterly movement while steadily strengthening, becoming a severe tropical storm on 7 August about 700 km south-southwest of Wake. Typhoon intensity was reached on 9 August about 1,300 km east-northeast of Guam, with Kent packing 175 km h^{-1} winds. The storm then began moving west-northwest through 11 August as it strengthened to a peak intensity of 240 km h^{-1} on 12 August. Kent then turned to a northwesterly track as it started to weaken, and this general course continued through 14 August. Kent turned back to a west-northwest track on 15 August and weakened to a Severe Tropical Storm 820 km south of Tokyo the next day with 100 km h^{-1} winds. Kent returned to a northwest course toward Japan on 17 August, landing over the east coast of Kyushu on 18 August. It then turned north across Kyushu and western Honshu. At 2027 UTC 17 August, Kanoya, Japan reported northerly winds at 65 km h^{-1} with gusts to 115 km h^{-1}, and a central pressure of 988 hPa was registered there at 0000 UTC 18 August. Kent weakened while over Japan, and moved north-northeast into the Sea of Japan on 19 August as a weak depression. Dissipation followed the next day near 38N 133E over the Sea of Japan. Press reports indicate that in southern and western Japan five people were swept away by high waves and two others were missing.

Tropical Storm Lois (9212)

Tropical Depression 12W formed near 16N 129E, about 850 km east-northeast of Manila on 15 August. Initially moving northwest, the system turned northeast on 16 August as it reached tropical storm intensity with 65 km h^{-1} winds some 1,000 km northeast of Manila. Lois continued a generally northeast motion under the influence of the prevailing southwest monsoon throughout the rest of its life. The structure remained generally poorly organized as a result with winds reaching a peak intensity of only 75 km h^{-1} on 18 August. This intensity was maintained until Lois finally weakened to a depression on 21 August some 900 km east of Tokyo. The system dissipated the next day near 38N 154E in the north Pacific Ocean.

**Tropical Storm Mark (9213)*

Tropical Depression 13W formed on 16 August near 21N 117E in the vicinity of Dongsha, about 330 km east-southeast of Hong Kong. The Stand By Signal #1 was hoisted at 1015 HKT shortly after its formation and when it was about 320 km east-southeast of Hong Kong. This system moved slowly and erratically at first making a counter-clockwise loop around Dongsha during the day before moving northward through the South China Sea at about 8 km h^{-1}. It reached tropical storm intensity the next day with 75-85 km h^{-1} winds. Mark drifted slowly northward to north-northeastward towards the Taiwan Straits with winds remaining near the peak intensity of about 85 km h^{-1}. As Mark was moving away from Hong Kong during this time the Stand By Signal #1 was lowered at 1130 HKT on 17 August when the storm was about 400 km to the east. Mark weakened to a tropical depression on the evening of 18 August before it turned north-west and moved towards the Chinese coast. It re-intensified briefly to a tropical storm just before making landfall about 20 km northeast of Shantou. Mark lingered near the Chinese coast moving south-southwestwards through 20 August with tropical storm force winds affecting parts of the coast before it weakened rapidly to an area of low pressure as it moved out to sea and drifted slowly westwards. The remnant dissipated near 22N 114E, about 60 km south of Hong Kong on 21 August. One person was killed, two people injured and another reported missing in eastern Guangdong. Heavy rain around Shantou caused serious flooding of farmland. No damage or casualties were reported in Hong Kong. Figure 5 shows the track of Tropical Storm Mark.

Tropical Storm Nina (9214)

Tropical Depression 14W formed over the western north Pacific near 26N 160E, about 1900 km east of Iwo Jima, on 18 August. Initially moving north-northeast and then north-northwest, the system strengthened to Tropical Storm Nina the next evening when it was about 1,650 km east-southeast of Tokyo. A peak intensity of 85 km h^{-1} was reached on 20 August as Nina recurved north-northeastwards and then eastwards. Rapid weakening then followed, and Nina dissipated early on 22 August near 40N 172E, some 3,000 km east-northeast of Tokyo.

Typhoon Omar (9215)

Tropical Depression 15W formed over the Caroline Islands about 1,350 km east-southeast of Guam near 8N 156E on 24 August. Moving west-northwest, the system became Tropical Storm Omar the next day. Omar turned more west on 26 August, continued to intensify and move west reaching severe tropical storm strength on 27 August. Rapid strengthening then occurred as the system headed for Guam and typhoon intensity was attained about 140 km east-southeast of Guam on 28 August. The eye of Omar passed directly over Guam around 0700 UTC 28 August. At 0640 UTC Andersen Air

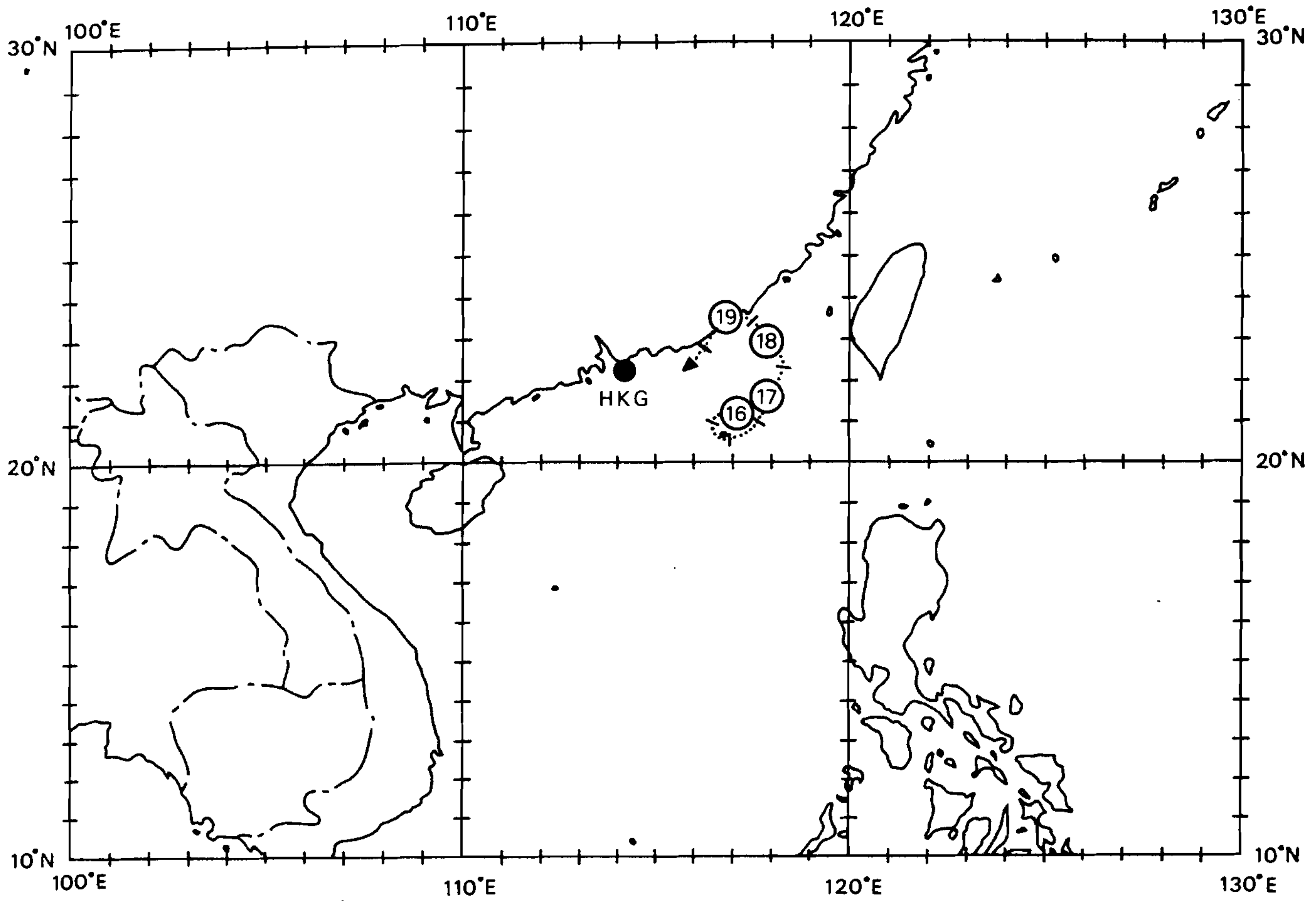

Figure 5 Track of Tropical Storm Mark (9212), 16 - 19 August, 1992 (after Royal Observatory, Hong Kong)

Force Base at the north end of the island reported 165 km h^{-1} sustained northeasterly winds gusting to 240 km h^{-1}. At 0655 UTC the base was inside the eye reporting a pressure of 945.8 hPa with 50 km h^{-1} easterly winds gusting to 115 km h^{-1}. The typhoon continued west away from Guam, then it turned west-northwest later that day. Omar reached a peak intensity of 240 km h^{-1} on 29 August as it continued west-northwest at 20 km h^{-1}, then it turned northwest on 30 August with 210 km h^{-1} winds. Omar's strike on Guam was devastating with one person reported killed, over 100 injured and thousands left homeless. Some 85% of the island was without power and the Joint Typhoon Warning Center was put out of action. All warnings on Omar after striking Guam were issued by the Alternate Joint Typhoon Warning Center at the Naval Western Oceanography Center in Hawaii. Omar continued a general west-northwest track through 3 September as it slowly weakened. The storm then moved west and weakened to severe tropical storm intensity later on 3 September. Omar moved westward across Taiwan on 4 September. Chiayi reported sustained winds of 88 km h^{-1} with gusts to 125 km h^{-1} at 2100 UTC, while Hsinchu reported a minimum pressure of 982 hPa at 1800 UTC. In Taiwan two people were killed and 12 others injured. Flooding occurred in five counties and there was widespread interruption of power supply. Omar then continued westward into China on 5 September, making landfall near Xiamen. Over land it rapidly dissipated becoming a tropical depression about 160 km west of Xiamen that night. On the 6 September the remnant weakened into an area of low pressure as it tracked west-southwestwards across Guangdong. In Hong Kong this produced localized heavy rain and extensive flooding in the northwest New Territories on 7 September.

Tropical Storm Polly (9216)

Tropical Depression 16W formed on 25 August near 18N 140E, some 2,000 km east-northeast of Manila. The system moved generally west-northwest as it slowly strengthened to tropical storm intensity on 27 August. During that time, internal structural readjustments took place as multiple storm centres developed. Polly continued west-northwest through 28 August, then it turned northwest toward Taiwan on 29 August developing into a severe tropical storm. Polly crossed the northern end of Taiwan on 30 August moving north-northwest with maximum winds of around 90 km h^{-1}. At that time Polly was a large system with many monsoon depression characteristics. Tropical storm force winds occurred over Taiwan, the southwestern Ryukyus, and much of the adjacent ocean regions. There are numerous ship reports of 75-90 km h^{-1} winds, with Ship 4XGR reporting 110 km h^{-1} well east of the centre at 1200 UTC 30 August. Maximum winds at the land stations on Taiwan were 55-75 km h^{-1} with higher gusts. Minimum pressure reported was on Taiwan at 977 hPa, with several stations reporting pressures below 980 hPa. Polly continued to move generally northwest towards Fujian province, China on 31 August as it weakened to a depression about 140 km west-northwest of Fuzhou early on 1 September. Polly dissipated as a tropical cyclone shortly afterwards. However, the remnant low turned north-northeast over the East China Sea and reached the Sea of Japan before losing its cyclonic identity. As a consequence its effects extended as far as Shandong province where 24 people were reported killed and where oil production was disrupted.

Typhoon Ryan (9217)

Tropical Depression 17W formed near 18N 149E, about 700 km northeast of Guam, on 1 September. Moving erratically westward, the system reached tropical storm intensity later that same day. The storm then drifted slowly northward on 2 September as it continued to intensify. Further intensification occurred on 3 and 4 September as Ryan drifted erratically. It reached typhoon intensity near 19N 147E, about 660 km north-northeast of Guam, early on 4 September. The system then started moving northward on 5 September and accelerated to 20 km h^{-1} towards the north-northeast on 6 September as it reached a peak intensity of 195 km h^{-1}. It then turned north on 7 September and west-northwest towards Japan on 8 September while slowly weakening. Movement next changed to northwest on 9 September with Ryan crossing the Kuril Islands that night at 65 km h^{-1}. Recurvature to the north-northeast occurred on 10 September with weakening to a severe tropical storm occurring about 1400 km north-northeast of Tokyo. Ryan then accelerated northward on 11 September as it weakened to a tropical storm. The system became extratropical on 12 September in the Sea of Okhotsk near 49N 148E, about 800 km north-northeast of Sapporo, Japan.

Typhoon Sybil (9218)

Tropical Depression 18W formed near 19N 165E, about 170 km west-southwest of Wake Island, on 4 September. The system moved generally northeast through 5 September, affecting Wake with sustained winds of 45-55 km h^{-1} and gusts to 75 km h^{-1}. It then became nearly stationary near 23N 166E on 6 September before moving south-southeast and reaching tropical storm intensity on 7 September about 150 km north-northeast of Wake Island. Sybil then began to drift slowly south-southeast during 8 September, before turning north-northeast as it reached typhoon intensity about 100 km east-southeast of Wake the next morning. At this time it began to move northwards and accelerated to 25 km h^{-1}. Sybil abruptly turned west-northwest on 10 September, and the storm continued this general motion the next day as it reached a peak intensity of 210 km h^{-1}. Sybil then moved northwest on 12 September and recurved to the northeast on 13 September as it weakened to a severe tropical storm with 130 km h^{-1} winds about 1,350 km east of Tokyo. Wake Island reported maximum sustained winds of 77 km h^{-1} with gusts to 94 km h^{-1} with a minimum pressure of 986.5 hPa. Several hours of reports were lost due to communications failures, and it is possible that higher winds and lower pressures occurred during this time. Sybil turned to a general northeast track the next day as it weakened to a tropical storm about 1,850 km east-northeast of Tokyo. The system became extratropical on 15 September near 40N 163E, some 2,100 km east-northeast of Tokyo.

Tropical Storm Ted (9219)

Tropical Depression 19W formed near 15N 138E, about 1,800 km east of Manila, on 18 September. Moving generally west-northwest at 25 km h^{-1}, the system became Tropical Storm Ted later that same day when about 1,150 km east of Manila. Ted turned northwest on 19 September, then turned back to a west-northwest track the next day. It maintained this course as it approached the Philippine island of Luzon, slowly strengthening. Ted turned northwest on 21 September and reached a peak intensity of 120 km h^{-1} while just north of Luzon, some 600 km north-northeast of Manila. According to press reports three people were killed in the Philippines due to flooding and mudslides. After slowing to 5 km h^{-1}, Ted turned north on 22 September and crossed eastern Taiwan as a tropical storm. Taipei was passed closeby that evening and reported a minimum pressure of 988 hPa. No tropical storm force winds were reported from any observing stations on Taiwan but floods and landslides were triggered by the passage of Ted. The storm continued northward along the Chinese coast making landfall near Wenzhou on the morning of 23 September. Ted weakened to a tropical storm about 150 km northwest of Shanghai on 24 September. There were reports of heavy damage associated with torrential rain in Jiangsu and Zhejiang provinces of eastern China with at least 53 people killed and another 51 reported missing. After crossing the Yellow Sea Ted traversed Korea on the evening of 24 September. It weakened to a tropical storm about 650 km northwest of Tokyo the next morning and became extratropical over the Sea of Japan later that day.

Tropical Storm Val (9220)

Tropical Depression 20W formed near 13N 160E, about 1,650 km east of Guam, on 23 September. The system moved northwest initially, then turned north the next day as it reached tropical storm intensity about 1, 500 km northeast of Guam. Val moved generally northward through the rest of its life, with an acceleration of the forward speed to about 35 km h^{-1} on 26 September. A peak intensity of 85 km h^{-1} was reached on 25 September, and Val maintained this intensity while recurving northeastwards until it became extratropical near 43N 156E about 1,600 km east-northeast of Tokyo on the evening of 27 September.

Typhoon Ward (9221)

Tropical Depression 21W formed close to the International Date Line near 15N 180W, about 1,500 km east-southeast of Wake Island, on 26 September out of a persistent area of disturbed weather that originally developed southwest of Hawaii. Moving generally west-northwest, the system became Tropical Storm Ward the next day, with 85 km h^{-1} winds. Ward moved slowly northwest on 28 September, then it turned north on 29 September as it reached typhoon intensity about 150 km east of Wake. The storm turned northwestward at a speed of 30 km h^{-1} on 30 September and west at a slower speed of 25 km h^{-1} on 1 October. It then moved west-southwest on 2 October as it reached a peak intensity of 185 km h^{-1}. Ward turned back to the northwest on 3 October, and moved northward once again, at 10 km h^{-1} on 4 October with 155 km h^{-1} winds. Ward continued moving north on 5 October, then it accelerated northeastward as it weakened to a tropical storm about 1,750 km east of Tokyo on 6 October. It continued to accelerate northeastward and became extratropical the next day near 45N 172E, about 2,900 km east-northeast of Tokyo.

Typhoon Yvette (9223)

Tropical Depression 23W formed 1,080 km east of Manila near 15N 131E on 8 October. Moving

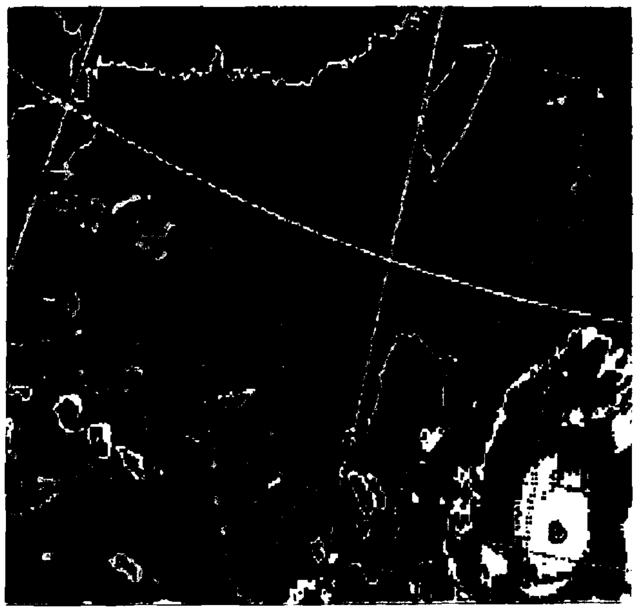

Figure 6 GMS-4 IR image of Typhoon Yvette (9223) east of Luzon at 0900Z, 10 October, 1992

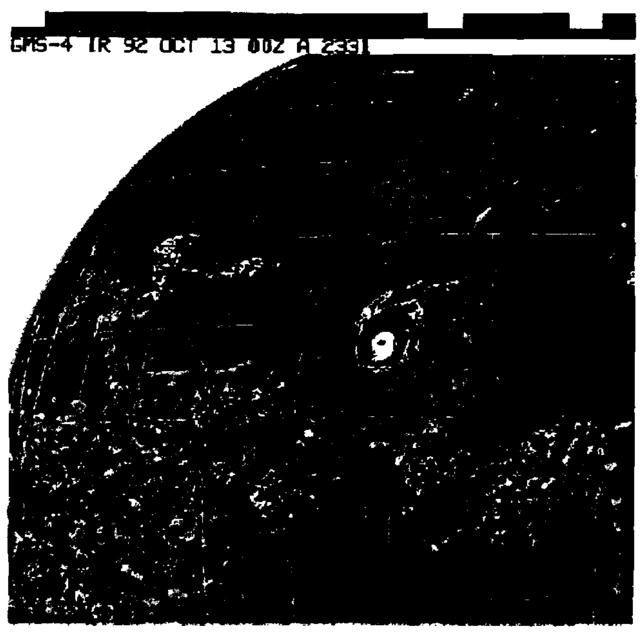

Figure 7 GMS-4 IR image of Typhoon Yvette (9223) tracking north-northeast at 0000Z, 13 October, 1992

west, it became Tropical Storm Yvette later that day. Yvette continued to move west during 9 October intensifying to a severe tropical storm about 550km east of Manila that evening. The storm then stalled in its westward movement as it reached typhoon intensity about 520 km east-northeast of Manila on 10 October (Figure 6). The storm rapidly strengthened the next day as it drifted slowly northward. Yvette reached an intensity of 250 km h^{-1} on 11 October as it drifted north-eastward east of the Philippines. Yvette continued northeast through 12 October, then turned north-northeast on 13 October (Figure 7) and continued this track through the next day. Winds dropped off to 200 km h^{-1} on 12 October, but then a major re-intensification began. Yvette reached a peak intensity of 285 km h^{-1} on 14 October based on 3 independent Dvorak satellite classifications of T7.5. This would yield an ESTIMATED minimum central pressure of 885 hPa. Yvette started to weaken on 15 October as it turned northeast and began moving at 30 km h^{-1}. This general track was maintained until the storm became extratropical. Yvette dropped below typhoon intensity on 17 October just after passing to the north of the Ogasawara Islands and weakened to a tropical storm that night about 710 km southeast of Tokyo. The system became extratropical near 31N 146E on 18 October. Fortunately for the residents of the region, Yvette stayed far enough from any land mass to avoid causing serious effects.

Tropical Storm Zack (9222)

Tropical Depression 22W formed on 7 October near 9N 171E, some 1200 km south-southwest of Wake Island. The system was initially moving west, and this motion continued through 8 October. Tropical storm intensity was reached on 9 October about 1,400 km southwest of Wake with 65 km h^{-1} winds as Zack turned west-northwest. Zack then turned to an erratic east-northeast drift at 30 km h^{-1} on 10 October, and then drifted northward on 11 October as it weakened to a depression some 850 km southwest of Wake. This erratic northward motion continued through 12 October when it turned west-northwest on 13 October as it began to re-intensify. During this time, the centre passed over Minamitorishima (Marcus Island). Zack failed to re-intensify and moved northwards, with occasional westward drift, before dissipating early on 16 October some 1,700 km northwest of Wake.

Typhoon Angela (9224)

Tropical Depression 24W formed in the South China Sea near 14N 119E, about 300 km west-southwest of Manila, on 16 October. Drifting west at 12 km h^{-1} while continuing to intensify, the system reached tropical storm status about 340 km west-southwest of Manila the next day. Continuing to intensify but shifting to a southwest track Angela reached severe tropical storm strength about 570 km west-southwest of Manila on 18 October and reached typhoon intensity later that day, moving west with 130 km h^{-1} winds. Angela turned west-northwest the next day as it reached a peak intensity of 165 km h^{-1}, then it continued a general west-northwest drift on 20 October as it weakened. Angela drifted north on 21 October while weakening to a tropical storm, then it assumed a westward track on 22 October moving at a speed of 9 km h^{-1} towards the coast of Vietnam. The westward motion continued through 23 October as Angela made landfall about 400 km northeast of Ho Chi Minh City, Vietnam as a 100 km h^{-1} tropical storm. Angela continued inland and dissipated the next day. The remains drifted out over the Gulf of Thailand on 26 October and regenerated into a tropical depression near 8N 102E, about 510 km west-southwest of Ho Chi Minh City, on the evening of 27 October. Angela regained tropical storm intensity later that day, and then regained minimal typhoon intensity the next day while it remained quasi-stationary in the Gulf of Thailand. This typhoon phase was very short lived, and by the evening of 28 October it had weakened again to a tropical storm. Angela drifted northward into the Vietnamese coast on 29 October as it weakened to a tropical depression about 490 km west-southwest of Ho Chi Minh City. The system crossed the west coast of southern Vietnam on 30 October and dissipated later that day near 9N 102E as it moved into Cambodia. The slow movement of Angela over the South China Sea led to prolonged windy conditions in Hong Kong during the latter part of the month. However, the damage associated with the storm was confined to Vietnam and Cambodia and to a lesser extent Thailand. In Vietnam flooding reportedly killed 47 people, 7 were reported missing and many others injured and caused serious damage to farmland and communications. In Thailand two people were killed and seven reported missing after their boat capsized.

Typhoon Brian (9225)

Soon after the formation of Angela Tropical Depression 25W formed out in the Pacific near 11N 160E, some 1,700 km east-southeast of Guam, on 17 October and moved west at 20 km h^{-1}. It intensified to tropical storm strength about 1,250 km east-southeast of Guam the next day as it moved southwest with 55 km h^{-1} winds. It turned west on 19 October and became a severe tropical storm about 450 km southeast of Guam with 100 km h^{-1} winds. Rapid strengthening occurred during that day, with winds reaching typhoon intensity as Brian became quasi-stationary near 12N 148E, about 400 km east-southeast of Guam. Brian next turned west-northwestwards later on 20 October as it reached a first peak intensity of 175 km h^{-1}. The system turned northwest and crossed over the southern end of Guam with winds estimated at 165 km h^{-1} early on 21 October. Andersen Air Force Base reported 74 km h^{-1} winds gusting to 103 km h^{-1} with a minimum pressure of 998.8 hPa. On the island 4 people were injured and power and water supplies disrupted. The storm continued north-west after hitting Guam, then it turned north-northwest on 22 October reaching a peak intensity of 185 km h^{-1} about 450 km northwest of Guam. Brian continued a generally north-northwest track through 23 October, then it recurved northeastward and accelerated as it weakened to a severe tropical storm about 850 km south of Tokyo on 24 October. Moving rapidly at 70 km h^{-1} Brian further weakened to a tropical depression about 770 km east-southeast of Tokyo on 25 October and became extratropical near 34N 150E later that day.

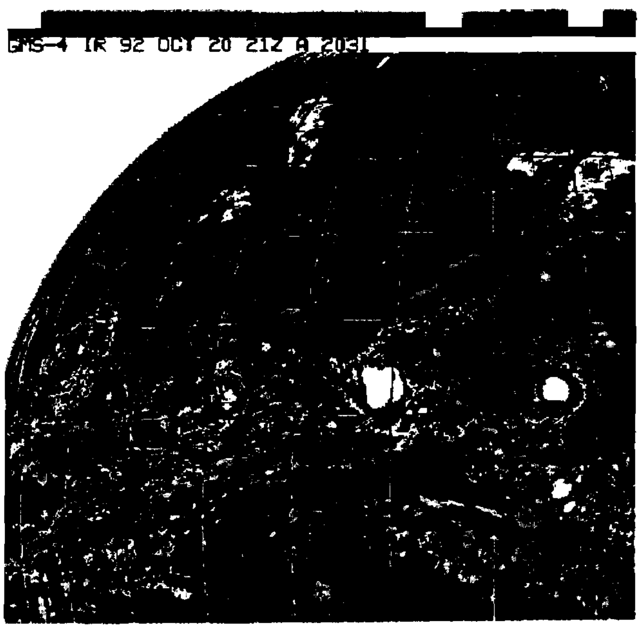

Figure 8 GMS-4 IR image of Typhoons Angela (9224), Brian (9225), and Colleen (9226) at 2100Z, 20 October, 1992

Typhoon Colleen (9226)

While two tropical storms, Angela and Brian were active in the region Tropical Depression 26W formed about 1,200 km east-southeast of Manila on 18 October and drifted west-northwest with 75 km h^{-1} winds. Colleen continued a general west-northwest track through 19 October as it continued to gain in strength. It then drifted erratically to the east of the central Philippines for the next three days in the vicinity of 14N 131E as it interacted with Typhoon Brian. During this time it continued to strengthen reaching typhoon intensity about 1,070 km east of Manila on 22 October. Colleen reached a peak

Figure 9 GMS-4 IR image of Typhoon Colleen (9226) crossing southern Luzon at 2100Z, 25 October, 1992

intensity of 150 km h^{-1} that day and then it started weakening on 23 October as it assumed a course towards the west-northwest. Colleen weakened to a tropical storm on 24 October as it moved first north and then west. Then, Colleen assumed a west-southwest track on 25 October as it regained typhoon intensity just east of Luzon in the Philippines. Colleen moved through the Philippines south of Manila (Figure 9) on 26 October and into the South China Sea. The passage brought heavy rain to the central Philippines and one woman was reported drowned. Many roads in the mountains were also blocked by landslides. The system briefly weakened to a tropical storm during the crossing, but it regained minimal typhoon intensity later that day. Colleen moved west-southwest across the South China Sea at 20 km h^{-1} during 27 October before turning west -northwest that evening until it made landfall in Vietnam about 200 km south-southeast of Danang on 28 October. The system maintained minimal typhoon intensity until this time, then it weakened to a tropical storm just prior to landfall. Colleen continued west over land, weakening to a tropical depression over Laos, and dissipated over central Thailand the next day.

Typhoon Dan (9227)

Although this system originated in the Central North Pacific, the Central Pacific Hurricane

Center issued no advisories on it. Tropical Depression 27W formed on 24 October near 11N 178W, about 1,900 km east-southeast of Wake Island. Moving west, the system crossed into the Western North Pacific on 25 October as it reached tropical storm intensity with 75 km h^{-1} winds and tracked west-northwest at 22 km h^{-1}. Dan turned west-northwest on 26 October as it attained severe tropical storm intensity about 1,200 km east-southeast of Wake. It soon reached typhoon intensity, about 620 km south-east of the island and it continued this track as it intensified and moved towards Wake the next day. Dan turned northwest on 28 October as it reached a peak intensity of 210 km h^{-1} while passing near Wake, which reported sustained winds of 110-130 km h^{-1} with gusts over 165 km h^{-1} along with a minimum pressure of 980 hPa. Dan stalled near 23N 164E on 29 October as it weakened, then it assumed a west-southwest track the next day as winds dropped to 140 km h^{-1}. Dan maintained this intensity through the next day as it turned west. Then it re-intensified on 1 November as it turned northwest at 25 km h^{-1} with 195 km h^{-1} winds, which turned out to be the peak of its last intensification. Dan turned northeast on 2 November, and it accelerated at a speed of 45 km h^{-1} northeastward the next day as it weakened to a tropical storm about 1,130 km east-southeast of Tokyo and became extratropical near 33N 162E on 4 November.

Typhoon Elsie (9928)

Tropical Depression 28W formed near 8N 151E, about 940 km southeast of Guam, on 29 October. Initially moving erratically north-northwest, the system turned west-northwest the next day as it reached tropical storm intensity when about 780 km southeast of Guam. Elsie turned westward through the Caroline Islands at a speed of 15 km h^{-1} on 31 October as it reached typhoon intensity, with a first peak intensity of 155 km h^{-1} being achieved later that day. Elsie moved erratically northwest toward Guam on 1 November, approaching the island with 150 km h^{-1} winds. Elsie veered to the west-northwest temporarily on 2 November before resuming a northwest track later that day. This course change kept the strongest part of the storm away from Guam, about 130 km to the southwest, and, while the pressure on the island went down to 995 hPa, reported sustained winds remained below tropical storm force. Elsie intensified on 3 November as it turned to a west-northwest track which it continued through the next day. Elsie then turned north-northwest on 5 November as it reached a peak intensity of 275 km h^{-1}. The storm turned north-northeast and accelerated on 6 November while weakening, then it turned east-northeast and became a typhoon-force extratropical low near 32N 145E on 7 November.

Tropical Depression (9229)

Tropical Depression 29W formed near 18N 170E, 390 km east-southeast of Wake Island, on 1 November. Later that day, it moved westward near Wake which reported a minimum pressure of 1,007 hPa and 46 km h^{-1} sustained winds. The system turned north-northwest on 2 November and disspated later that day near 23N 159E. Maximum winds in this short-lived system were just under 55 km h^{-1}.

Tropical Storm Forrest (9230)

This system originated from an area of disturbed weather to the east of the Philippines. After crossing the Philippines Tropical Depression 30W formed in the South China Sea near 9N 114E, about 820 km east-southeast of Ho Chi Minh City, Vietnam, on 12 November. Moving initially west, the system turned west-southwest the next day as it reached tropical storm intensity and tracked westwards at 25 km h^{-1}. Forrest reached a peak intensity of 110 km h^{-1} shortly before moving into the Isthmus of Kra near Phuket, Thailand on 15 November. Forrest continued westward into the Andaman Sea with 90 km h^{-1} winds to become Tropical Cyclone Forrest. Forrest affected southern Vietnam, and the storm is blamed for the crash of a Vietnamese airliner with 30 people on board on 14 November. It is believed that all aboard were killed. In the Andaman Sea Forrest first moved west, then turned west-northwest on 16 November and continued on this track as it slowly strengthened. It re-intensified to a tropical storm about 900 km south-southwest of Yangon on 17 November and became a severe tropical storm that night. The system turned north on 18 November as it reached hurricane intensity over the Bay of Bengal about 950 km west of Yangon. This track continued the next day when Forrest reached a peak intensity of 230 km h^{-1}. It then turned east-northeast and made landfall near Sittwe, Myanmar on 21 November. The storm was steadily weakening as it approached the coast with maximum winds at landfall estimated at 175 km h^{-1}. Gusts to 103 km h^{-1} were reported at Cox's Bazar, Bangladesh about 110 km north of the centre as Forrest moved inland. Once over land the strom weakened rapidly as it dissipated over Myanmar the next day. Some damage to property and livestock was reported in the coastal regions of both Bangladesh and Myanmar but only one person has been reported killed as a result of the storm.

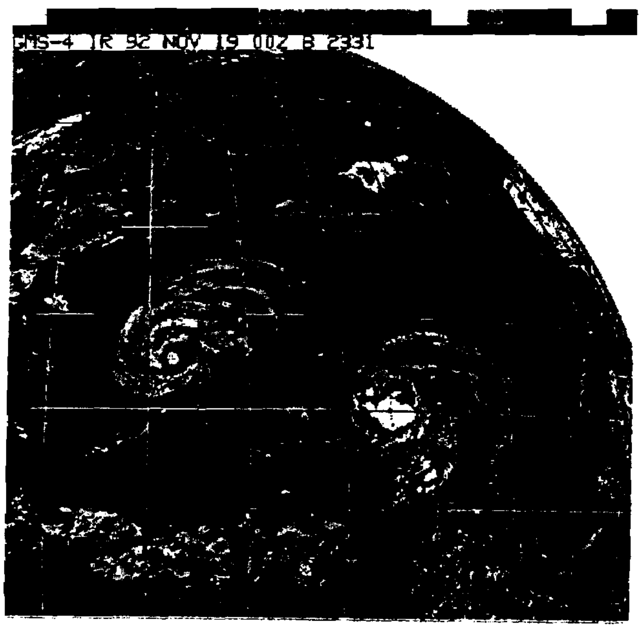

Figure 9 GMS-4 IR image of Typhoons Hunt (9232) and Gay (9231) at 0000Z, 19 November, 1992

Typhoon Gay (9231)

Tropical Depression 31W formed near 7N 178E over the Marshall Islands about 750 km east of Majuro on 14 November. Moving moving west-northwest, the system reached tropical storm intensity the next day as it passed through the Marshall Islands with 140 km h^{-1} winds. The storm continued its west-northwest for the next two days as it reached typhoon strength about 570 km northwest of Majuro on 17 November. At 0000 UTC 17 November, Wotje Atoll reported 120 km h^{-1} winds with gusts to 148 km h^{-1}, while Mejit Atoll estimated gusts of 165 km h^{-1}. From 16-18 November the passage of Gay across the Marshalls left one person dead and 5,000 homeless. Gay turned west at 20 km h^{-1} on 18 November and continued this course through 21 November as it strengthened into one of the most intense typhoons in the last 13 years (Figure 9). Maximum winds reached a peak of 295 km h^{-1} on 20 November, which is just short of the peak intensity of Typhoon Tip in 1979. Fortunately, this took place while Gay was far from land. Gay slowly weakened after 20 November, and it turned west-northwest toward Guam on 22 November with winds estimated at 230 km h^{-1}. The eye of Gay passed directly over Guam at 0000 UTC 23 November. While the Joint Typhoon Warning Center was estimating sustained winds of 185-210 km h^{-1} as the eye crossed the island, there is a possibility that Gay was somewhat weaker than this, as maximum reported winds on the island were 155 km h^{-1} with gusts to 194 km h^{-1} at the Joint Typhoon Warning Center. Minimum pressure in the eye was 972 hPa at Agana. No significant damage or casualties have been reported from Guam, although power was knocked out on most of the island. Gay continued west with winds estimated near 185 km h^{-1}. The storm turned west-northwest at about 20 km h^{-1} on 24 November, then it turned northwest on 25 November as it started re-intensifying. A secondary peak intensity of 230 km h^{-1} was reached later that day. Gay stalled near 18N 132E as it weakened on 26 November, then the system started a northwest drift the next day. Gay finally turned north at 13 km h^{-1} on 28 November, then it moved north-northeast on 29 November as it weakened to a tropical storm with 85 km h^{-1} winds about 560 km south-south-east of Okinawa. The storm continued to weaken to a depression about 280 km southeast of Okinawa before becoming extratropical near 26N 131E.

Typhoon Hunt (9232)

A tropical depression formed near 13N 159E, about 1,550 km east of Guam, on 15 November. It was designated 32W by the Joint Typhoon Warning Center as it moved west-northwest at about 25 km h^{-1}. It turned west on 16 November, and this motion continued the next day as the system reached tropical storm intensity some 730 km east of Guam. Hunt turned west-northwest and passed about 40 km north of Guam as it reached typhoon intensity on 18 November. Andersen Air Force Base reported a minimum pressure of 987.2 hPa at 0500 UTC 18 November, with maximum sustained winds of 61 km h^{-1} and peak gusts of 99 km h^{-1} reported several hours later. Hunt turned north-northwest on 19 November as it reached a peak intensity of 230 km h^{-1} (Figure 9). Hunt recurved northeast on 20 November and accelerated to a forward motion of nearly 90 km h^{-1} while weakening rapidly. Hunt dropped below typhoon intensity on the night of 21 November about 1,200 km east of Tokyo and became extratropical near 40N 160E the following day.

Acknowledgements

Satellite images are GMS-4 IR images of the Japanese Meteorological Agency, Tokyo downloaded and processed at James Cook University of North Queensland, Australia using a commercial system, *JCUMetSat*, developed at that institution. From there they were obtained by anonymous ftp through Internet. All sources are gratefully acknowledged.

Meeting Reviews

ASAIHL Seminar

Venue: The University of Hong Kong

Date: 17 - 20 June, 1992

Several members of the Society contributed papers to the Association of Southeast Asian Institutions of Higher Learning (ASAIHL) Seminar on *he Role of ASAIHL in Combating Health Hazards of Environmental Pollution* organized by the University of Hong Kong in connection with its 80th Anniversary celebrations.

On 18 June, 1992 the following papers were presented:

Bill Kyle, Department of Geography & Geology, The University of Hong Kong:

> *CLIMATOLOGICAL ASSESSMENT OF POTENTIAL HEAT STRESS IN HONG KONG.*

Wyss W.S. Yim *and others*, Department of Geography & Geology, The University of Hong Kong:

> *FOLLOW-UP STREAM SEDIMENT GEOCHEMICAL RECONNAISSANCE SURVEYS IN THE VICINITY OF TAI MO SHAN, NT, HONG KONG.*

On 19 June, 1992 the following papers were presented:

C.N. Ng *and others*, Department of Applied Science, City Polytechnic of Hong Kong:

> *A PROPOSED AIR QUALITY INDEX FOR HONG KONG.*

M.R. Peart, Department of Geography & Geology, The University of Hong Kong:

> *A GEOGRAPHICAL APPROACH TO EVALUATING THE HUMAN IMPACT ON WATER QUALITY.*

Second International Conference on East Asia and Western Pacific Meteorology and Climate

The Second International Conference on East Asia and Western Pacific Meteorology and Climate was held from 7 to 10 September 1992 at Hong Kong Baptist College. The Conference was sponsored by the Society and supported by University Corporation for Atmospheric Research, USA, K.C. Wong Education Foundation Ltd., Hong Kong and Wei Lun Foundation Ltd., Hong Kong.

Altogether there were about 100 attendees from meteorology and related disciplines of whom 80 were invited/registered participants who met to share their knowledge and to exchange their research experiences through paper presentations and discussions. The following members presented the papers listed on the dates shown.

7 September, 1992

S.I. Hsu & W.L. Siu, Department of Geography, The Chinese University of Hong Kong:

> *DEBATE ON THE CLIMATE CHANGE OF THE SHANG DYNASTY IN CHINA.*

R. Lau & M.Y. Chan, Royal Observatory, Hong Kong:

LOW LATITUDE STRATOSPHERIC FLOW PATTERNS.

N.C. Lau *and one other*, GFDL/NOAA Princeton, Princeton, NJ, USA:

SIMULATION OF THE ASIAN SUMMER MONSOON IN A 40-YEAR EXPERIMENT WITH A GENERAL CIRCULATION MODEL.

K.L. Lee *and one other*, Department of Geography, The Chinese University of Hong Kong:

A NUMERICAL STUDY ON THE OROGRAPHIC EFFECT ON THE COLD SURGE IN SOUTHERN CHINA.

8 September, 1992

C.M. Shun, Royal Observatory, Hong Kong:

A CASE STUDY OF HEAVY RAIN IN HONG KONG USING THE ROYAL OBSERVATORY LIMITED-AREA MODEL.

J.C.L. Chan & K. Ngan, Department of Applied Science, City Polytechnic of Hong Kong:

THE ASYMMETRIC FLOW ASSOCIATED WITH TROPICAL CYCLONE MOTION.

G.R. McGregor *and others*, Department of Geography, Hong Kong Baptist College:

CLIMATIC REGIONALIZATION IN CHINA USING MULTIVARIATE STATISTICAL ANALYSIS.

9 September, 1992

C.P. Chang & *one other*, Department of Meteorology, USN Postgraduate School, Monterey, CA, USA:

WINTER MONSOON COLD SURGES AND THE EQUATORIAL DIVERGENCE OVER THE SOUTH CHINA SEA.

K.H. Lau, Department of Meteorology, University of Washington, Seattle, WA, USA:

RELATIONSHIP BETWEEN SYNOPTIC-SCALE TRANSIENT ACTIVITY AND SUMMERTIME INTRASEASONAL FLUCTUATIONS IN THE ASIATIC MONSOON REGION.

S.L. Hung & Y.S. Cheng, Department of Applied Science, City Polytechnic of Hong Kong; C.Y. Lam & C.M. Tam, Royal Observatory, Hong Kong:

AN OPERATIONAL CLASSIFIER FOR SATELLITE IMAGES.

Y.L. Cheng & S.L. Hung, Department of Applied Science, City Polytechnic of Hong Kong: C.Y. Lam & C.M. Tam, Royal Observatory, Hong Kong:

RAINFALL ESTIMATION USING GEOSTATIONARY METEOROLOGICAL SATELLITE IMAGES.

10 September, 1992

W.J. Kyle, Department of Geography and Geology, The University of Hong Kong:

SUMMER AND WINTER PATTERNS OF HUMAN THERMAL STRESS IN HONG KONG.

M.R. Peart, Department of Geography and Geology, The University of Hong Kong:

ACID PRECIPITATION IN HONG KONG.

The Proceedings of the Conference, containing a collection of refereed papers in English, is currently being edited by an Editorial Board under Chief Editors W.J. Kyle and C.P. Chang and is due to be published by World Scientific Publishing Company, Singapore later in 1993.

Research Forum 6

Venue: Hong Kong Baptist College

Date: 12 December, 1992

Subject: Short Term Climate Fluctuation

A sixth research forum was held at the Lecture Theatre 1, Science Tower, Hong Kong Baptist College with the theme of *Short Term Climate Fluctuation.*

The first session was chaired by Dr. Glenn R. McGregor of the Department of Geography, Hong Kong Baptist College.

Two papers were delivered as listed.

SHORT TERM CLIMATE FLUCTUATION: AN OVERVIEW.

by Dr. W.L. Chang, Royal Observatory, Hong Kong

INTERANNUAL VARIABILITY OF TROPICAL CYCLONE ACTIVITY.

by Dr. Johnny C.L. Chan, Dept. of Applied Science, City Polytechnic of Hong Kong

Following a break for refreshments the second session was chaired by Dr. W.L. Chang of the Royal Observatory, Hong Kong.

Two papers were delivered as listed.

EL NINO AND HONG KONG WEATHER.

by Mr. C.Y. Lam, Royal Observatory, Hong Kong

RAINFALL VARIABILITY IN PAPUA NEW GUINEA.

by Dr. Glenn R. McGregor, Department of Geography, Hong Kong Baptist College

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Special Topics Lecture Series

Venue: Royal Observatory, Hong Kong

Date: 14 October, 1992

Subject: Tropical Rainfall Measurement Mission (TRMM)

Mr. Otto Thiele, Head of the TRMM Office, United States National Aeronautics and Space Administration (NASA) talked to members on the role of NASA in the Tropical Rainfall Measurement Mission.

Subject: Global Precipitation Climatology Project (GPCP)

Dr. Phillip Arkin, of the United States National Oceanic and Atmospheric Administration (NOAA) talked to members about the Global Precipitation Climatology Project.Both speakers were in Hong Kong in connection with a major Tropical Ocean Global Atmosphere (TOGA), Combined Ocean Atmosphere Research Experiment (COARE) Project meeting held in Guangzhou. The lectures were organized in conjunction with the Hong Kong University of Science and Technology Research Centre.

Venue: Royal Observatory, Hong Kong

Date: 4 November, 1992

Subject: Remote Sensing at NASA Langley Research Centre

A joint seminar presented by the Hong Kong University of Science and Technology and the Hong Kong Meteorological Society was conducted by Dr. William P. Chu, a senior research scientist at the Atmospheric Sciences Division, NASA Langley Research Center, Virginia, USA. The Center has been involved in the remote sensing of the atmosphere using groundbase, aircraft-borne, and spaceborne instruments since the early 1970s. Dr. Chu, who specializes in the retrieval of trace constituents vertical profiles from remote sensing data and in the development of advanced remote sensors for atmospheric sensing gave a brief summary of past and present efforts at Langley and then discussed future efforts such as the Stratospheric Aerosol and Gas Experiment (SAGEIII), in which he is a co-investigator, CERES and SAFIRE for the EOS program as well as the LITE mission.

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