香港氣象學會

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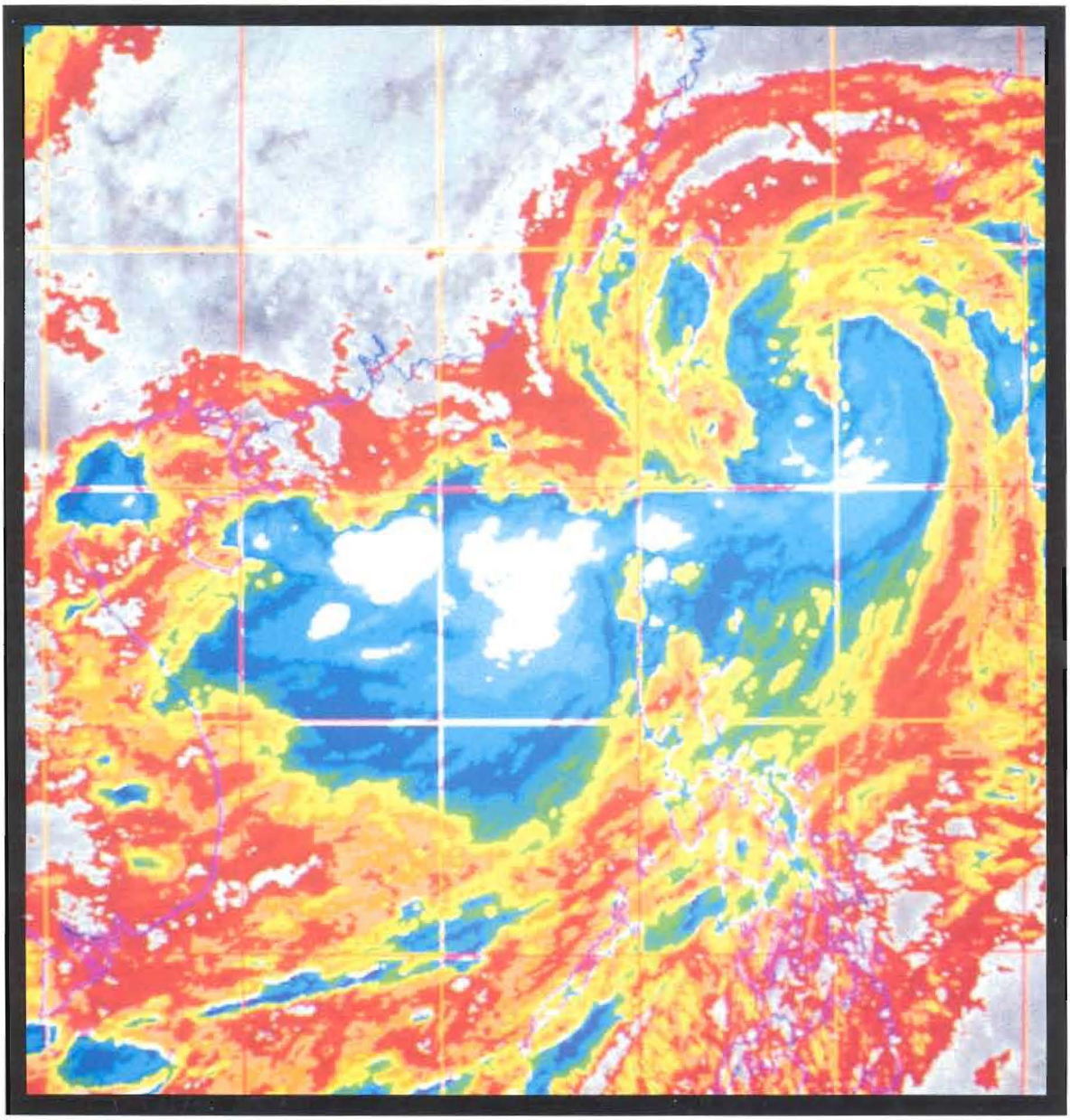
HONG KONG METEOROLOGICAL SOCIETY

BULLETIN



About the cover

The cover picture shows a G.M.S. colour enhanced picture of Typhoon Yancy around noon on 18th August, 1990, the hottest day ever recorded in Hong Kong

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

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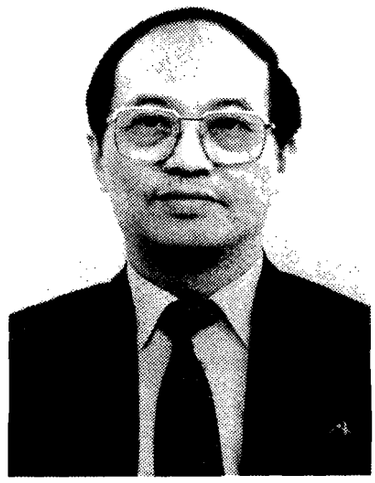

Editorial

On the special occasion of the inaugural issue of the Hong Kong Meteorological Society Bulletin the Editorial Board has invited Mr. P. Sham, founding Chairman of the Hong Kong Meteorological Society, to write this first Editorial.

Any new venture, whether it be a new job, a move to a new home, or even a new hobby presents opportunities as well as risks. The satisfaction which one derives from successful participation in such ventures often stems from the way in which we handle these two complementary attributes. You are now reading the first issue of the latest venture by the Hong Kong Meteorological Society. The level of satisfaction which you express with the finished product will be a measure of how successfully the Editorial Board has balanced the opportunities and risks associated with its production.

The Society itself is a new venture, being registered in accordance with the provisions of Section 5 of the Societies Ordinance just over two years ago, and holding its inaugural meeting in March 1989. It has had moderate success in its first two years of existence with the growth in membership being better than expected. The Executive Committee feels that this has been achieved by sustaining the interests of members by the variety of activities organized throughout the year. These have included a Special Topics Lecture Series, three Research Forums, and a Public Lecture Series. However, it has been felt for some time that it was essential for the Society to publish a regular magazine devoted to news, articles, activities and announcements of the Society. With this in mind an Editorial Board was formed and after a considerable gestation period produced the "*new baby*" which you are now holding.

As founding Chairman of the Society it gives me great pleasure to write this inaugural Editorial. A glance at the contents page of this first issue will provide you with a good idea of the range of material which the Editorial Board hopes to include in forthcoming issues of the *Bulletin*. The publication of articles which serve to inform members of progress being made in the profession is clearly of great importance but the capability to act as a forum for members views and as a vehicle for news and reviews of Society activities is also seen to be of considerable value.

The Editorial Board recognizes, however, that not all our members are professional meteorologists and so they need to ascertain what your interests and needs are. They are aware that a reader's trust and respect must be earned and fully intend to do their part. You can help them by turning the relationship into a dialogue. Let them know what you think of the *Bulletin*, what you want most to see on our pages. Like you, they are eager to listen and learn, to make each issue better and more responsive to the needs and aspirations of members than the previous one.

I hope that you find this first issue of the *Bulletin* interesting and informative and, through your continued support, the harbinger of many successful issues to come.

P. P. Sham

Mr. P. Sham, Chairman

Johnny C.L. Chan

Department of Applied Science

City Polytechnic of Hong Kong

Research in the atmospheric sciences in Hong Kong - a proposed agenda

Introduction

Research in the atmospheric sciences in Hong Kong probably started towards the end of the last century after the Royal Observatory (RO) was established (Royal Observatory, 1989). Although some occasional collaboration does take place between the RO and local or overseas institutes, most of the research has been performed at the RO. This situation has arisen because local tertiary institutes do not have departments specializing in atmospheric science. This is a consequence of the fact that the RO has been the only place where such graduates could go but its yearly intake of these graduates was too small to justify setting up departments with this speciality.

However, the situation has been slowly changing during the last few years. Concerns over the environment and climatic change have led to increased research in these areas in the tertiary institutes by scientists of related disciplines. Consultant companies dealing with environmental problems have also mushroomed. Graduates with knowledge in atmospheric or environmental sciences can find employment in these companies or even form their own! Academic departments which provide training in these areas are also being set up in some local tertiary institutes. At the same time, conservative budgeting by the government has limited the amount of resources available for its departments to carry out research and development work. Thus, research in the atmospheric sciences in Hong Kong appears to be taking on a new dimension. Cooperative research projects between the RO (and possibly other government departments) and local tertiary institutes are on the increase. More scientists in these institutes are also working on research problems related to atmospheric science.

This paper discusses a number of important topics in atmospheric science which are likely to be of interest to local scientists and proposes the type of research that could be carried out. It is hoped that such discussion can generate more ideas so that research in the atmospheric sciences in Hong Kong can continue to grow and eventually become respectable in the international community.

Hong Kong, situated near the Tropic of Cancer, is influenced by weather both from the tropics and the mid-latitudes. Research in weather phenomena affecting Hong Kong should therefore be divided into these two categories. However, such a division is not so clear-cut at times. For example, the severity of a cold surge can be influenced by the approach of a typhoon (*e.g.*, Chan, 1988a) while the track of a typhoon can also be modified by a cold surge (*e.g.*, Chan, 1988b). Therefore, in the following sections, the issues are grouped according to the time scales of the weather phenomena. The first section discusses the problem of nowcasting. The applicability of current numerical-weather-prediction (NWP) models to medium-range forecasting is then addressed. Because of their overwhelming importance to Hong Kong, tropical cyclones are separately discussed in the section after that. The hot topic of long-range weather forecasting and climatic change is discussed next and finally, a summary is presented.

Nowcasting

Nowcasting (or sometimes referred to as very-short-range forecasting) is usually defined as forecasting of weather with a time-scale of 0 to 6

hours. Tropical convective systems can be considered as the most important phenomenon in this category as far as Hong Kong is concerned. These systems, which have spatial scales of 20 to 200 km (the *meso-beta* scale as defined by Orlanski, 1975), can develop within a couple of hours and produce copious amounts of rain due to the high mixing ratio of the tropical atmosphere. Mesoscale convective elements developed within rainbands of tropical cyclones also fall in this category.

To be able to predict the development of these *meso-beta* convective systems, one must first understand the physical processes responsible for such developments. While the tropical atmosphere is conditionally unstable (*e.g.* Riehl, 1979), a triggering mechanism is often necessary for the initiation of convection. Possible mechanisms include (*a*) the destabilization of the boundary layer due to daytime heating over land leading to convective overturning, (*b*) low-level dynamical uplifting either from convergence associated with the synoptic-scale flow or due to land/sea breeze convergence, (*c*) upper-level divergence caused by transients on a synoptic scale, or (*d*) a combination of some or all of these mechanisms.

If the mechanisms responsible for the different types of convective systems can be identified, it might be possible to predict the occurrence and development of these systems. Identification of such mechanisms will also provide a better understanding of the physical processes involved. This can perhaps help in improving the performance of mesoscale models by incorporating such processes into the models. Research in this area will involve the study of a large number of previous cases to identify the triggering mechanisms. The recent study by Shun (1989) is a good start. Applying a mesoscale model such as that used at the RO (Yeung *et al.*, 1989) to test hypotheses related to the different triggering mechanisms is also important in the understanding of the underlying physical processes.

Medium-range forecasting

This may be defined as forecasts in the range of one to five days. Weather systems in this category which affect Hong Kong include tropical cyclones, easterly waves and equatorward extensions of mid-latitude frontal systems. Predictions of the behaviour of these systems have had limited success with the introduction of the regional (Chan, 1989) or global numerical models (Chan, 1988a). While improvements on the regional model of the RO continue to be made (Chan, 1989), the performance of these regional and global models under different situations should be analyzed. That is, questions such as "when should I believe the predictions from this model" need to be answered. Methods to predict the forecasting skill of numerical models have been developed (*e.g.*, Leslie and Holland, 1990) and could be applied. This type of research is not necessarily of a purely operational nature. Analyses of the model performance can provide clues as to how a model can be improved. The model-generated data (both analyses and prognoses) can be considered to be extra information for the understanding of the physical processes of these medium-range weather phenomena.

To the more theoretically-minded scientists, the dynamics of some of these weather systems may also be of some interest. For example, during a surge of the northeast monsoon in the wintertime, the cold air moves along the eastern coast of China at a speed far exceeding that explained by normal advection. Gravity-wave propagation has been proposed as a possible mechanism. Coastal Kelvin waves could also be involved. Research on these types of problems could eventually lead to an improvement in forecasting the arrival of such surges.

Tropical cyclones

Every year, about six tropical cyclones threaten Hong Kong (Royal Observatory, 1988). An accurate forecast can lead to tremendous savings in life and property. Unfortunately, our understanding of the physical processes of tropical cyclone (TC) motion and intensity change is far from complete. As a result, improvements in the prediction skill have been slow although recent studies indicate that global NWP models have some skill in TC forecasting (Reed *et al.*,1988; Morris and Hall, 1988; Chan and Lam, 1989).

The same question posed in the last section on the performance of NWP models can also be raised in this connection. In this case, analyses of model performance in predicting TC motion and intensity change can be made. Results of such a study are not limited to helping the forecaster to decide when to use the predictions. they can also point to the weaknesses of the model so that improvements can be made (*e.g.*, Chan *et al.*, 1987). Because TCs occur over the ocean where data are scarce, model analyses and prognoses can be considered to be extra data

sources in diagnosing the physical processes leading to the development/decay and movement of the model vortex.

On the more theoretical aspects, the dynamics of tropical cyclone movement needs to be studied much more. While studies using simple barotropic or baroclinic models are obviously necessary, analyses of observations could also lead to new understandings. During the summer of 1990, four different experiments were carried out in the western North Pacific to study tropical cyclones (Elsberry, 1989). These will provide the best data set ever for this region and will be available during 1991 for interested scientists. They should therefore provide many opportunities for tropical cyclone research in this area.

Long-range forecasting and climatic change

Over the last decade, much attention has been focussed on the seasonal or interannual variability of the tropical atmosphere. In particular, the amount of international research on the El Nino/Southern Oscillation and the 40-50 day (or 30-60 day) oscillation has grown tremendously, and this has progressively improved our understanding of these phenomena. However, not much has been done locally in this respect until the last few years. Research on the variability of temperature, rainfall or tropical cyclone tracks may lead to the development of seasonal forecast techniques. It will also improve our knowledge of the climatic variations in this part of the world so that any issue on climatic change (such as the recent discussions on the greenhouse effect and sea-level rise) can be addressed with greater confidence.

Summary

Research in the atmospheric sciences in Hong Kong has always been handicapped by the lack of enough academicians in the field. However, the growing concern over the environment and climatic change has led to an increase in the number of cooperative projects between the RO and scientist in local tertiary institutes. This paper has proposed a number of topics which the author believes should be addressed. The topics are not meant to be exhaustive. In fact, topics which are primarily of operational interest have been left out because meteorologists at the RO should be the people most suited to perform research in these problems. In any case, it is hoped that the proposals presented here will bring about further cooperation among the various organizations with an interest in atmospheric science in Hong Kong.

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C.Y. Lam

Royal Observatory

Hong Kong

"SPECTRUM" - Typhoons under critical examination

Introduction

To mark the commencement of the International Decade for Natural Disaster Reduction, the most comprehensive observation programme ever mounted by the meteorological community to study typhoons took place in the western North Pacific in August and September of 1990. Under the auspices of the ESCAP/WMO Typhoon Committee*, seven members, *viz*. China, Hong Kong, Japan, Malaysia, Philippines, Korea and Thailand, jointly conducted a SPecial Experiment Concerning Typhoon Recurvature and Unusual Movement (acronym: *SPECTRUM*). During the same observation period the United States and the USSR carried out separate, but complementary, observation programmes in the same geographical area. Taken together, these programmes produced an assembly of data of unprecedented resolution and areal coverage, describing both the large-scale environment surrounding typhoons as well as their individual circulation characteristics. Exciting possibilities lie ahead for meteorologists to delve into the data and to find out what controls the movement of typhoons.

This paper describes the background to *SPECTRUM* and some of the details of the data acquisition programme. It then outlines what is hoped for in terms of analysis of the data and issues an invitation to local scientists to apply the data to their ongoing or future research so that the opportunity to use such valuable data is not to be missed.

The need to observe typhoons

Typhoons annually bring a lot of damage to the members of the Typhoon Committee, either through direct hits or through indirect effects such as heavy rain brought about by the modification of synoptic patterns by the presence of a typhoon. Accurately predicting the tracks of typhoons is a key element in the warning operation to reduce the extent of damage. Global numerical weather prediction (NWP) models are increasingly capable of representing and forecasting typhoons realistically and usefully. However, front-line forecasters are all too aware of occasions when typhoons move in directions markedly different from those indicated by NWP models, especially in recurvature situations or when the environmental steering is weak. While inadequate data over the ocean might be partially responsible for some of the "wrong" predictions, it is also apparent that there are gaps in our understanding of the mechanism of typhoon movement. To address this problem, it is necessary to generate a comprehensive observational data set covering several typhoons which are difficult to forecast operationally. Subsequently, analysis can be carried out to evaluate the impact of data on forecasting accuracy as well as to elucidate the details of the physical mechanism of typhoon movement. This is the primary motivation behind *SPECTRUM*.

* ESCAP/WMO Typhoon Committee is a committee jointly sponsored by the Economic and Social Council for Asia and the Pacific (ESCAP), a United Nations body, and the World Meteorological Organization (WMO).

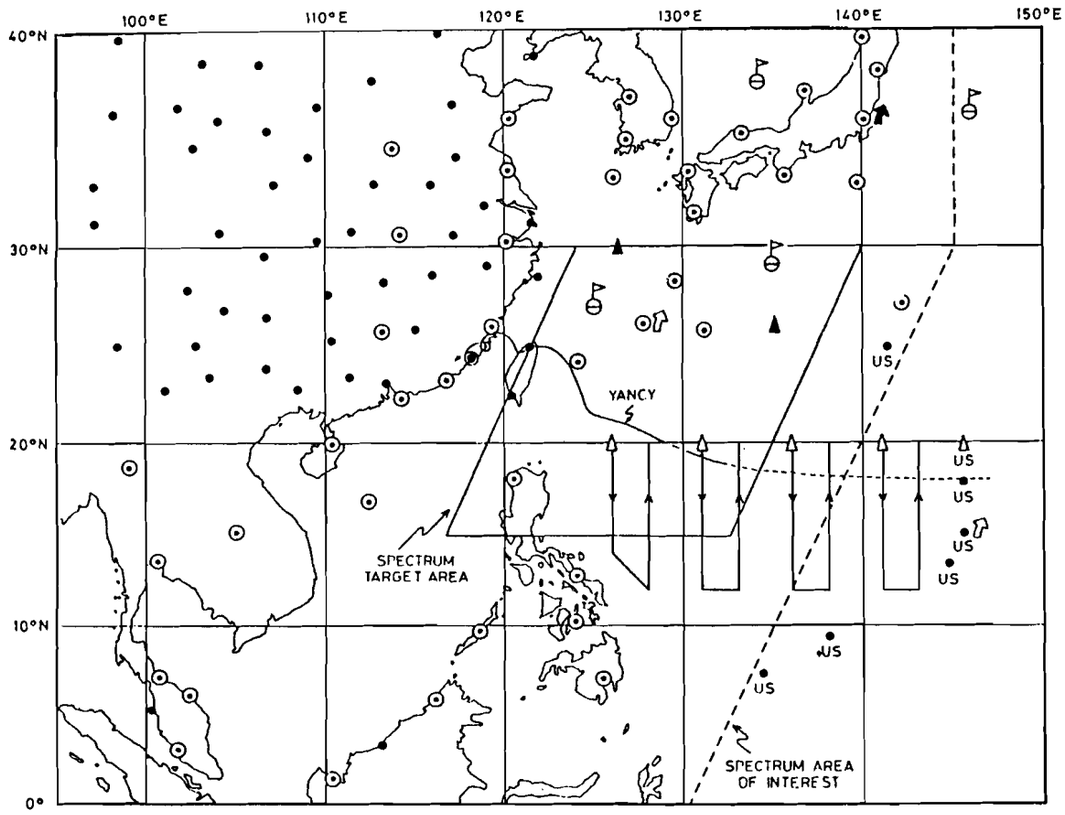

Figure 1 SPECTRUM observations: upper air sounding station (circled dot - 6-hourly, dot - 12-hourly); weather ship (solid triangle); buoy (flagged); wind profiler (solid arrow). Also shown are US and USSR weather ships (open triangle); US upper-air sounding stations and wind profilers (open arrow). The track of Typhoon Yancy (9012) is also shown. That part of the track covered by SPECTRUM and Chinese IOPs is shown as a continuous line.

The experiment

The overall objective of *SPECTRUM* is "***to obtain enhanced meteorological observational data required for studies by Typhoon Committee Members on the movement of tropical cyclones in the western North Pacific with a view to improving operational tropical cyclone forecasting***".

The Typhoon Centre operated by the Japan Meteorological Agency played the role of the *SPECTRUM* experiment centre. It was responsible for identifying target tropical cyclones and activating intensive observation periods (IOPs), following guidelines established by an international *SPECTRUM* Steering Group. A tropical cyclone would be selected only if it would persist for 2 - 3 days at least as a severe tropical storm, would cross a pre-specified target area, and would serve as an example of recurvature or movement close to a weakness in the subtropical ridge or movement in weak environmental flow. Throughout the *SPECTRUM* period, the experiment centre maintained operational contact with Members' operational centres which oversaw *SPECTRUM* activities within each Member's territory. While the experiment centre kept the Members informed about its intentions regarding IOPs, Members were also given the opportunity of letting it know their individual assessments of the synoptic situation.

The key component of the enhanced observation programme during the IOPs was 6-hourly upper-air observations made at more than forty stations on land and on board two weather ships (Figure 1). The spatial distribution of these observations was planned in such a way that would maximize their usefulness in future research work. Hourly surface observations were also made by some 230 synoptic stations during IOPs subject to certain additional criteria.

Over the sea, voluntary weather observing ships were requested to make 3-hourly obser-

vations during IOPs. Weather buoys and offshore platforms also contributed to this data gathering effort.

Apart from conventional observations, modern technology was also brought to bear on *SPECTRUM*. The Geostationary Meteorological Satellite (GMS) was operated to yield more cloud wind vectors at both high and low levels. Further to the enhancement of conventional radar observations, a doppler radar was operated at Miyakojima. A wind profiler which gave vertical profiles of upper air winds with high temporal resolution was operated at the Meteorological Research Institute at Tsukuba, Japan, during IOPs.

Most of the enhanced observations were transmitted to Tokyo immediately via the international meteorological telecommunication network called GTS. Special real-time monitoring procedures were implemented to ensure that all relevant bulletins would arrive in Tokyo on time.

During *SPECTRUM*, a total of seven typhoons were intensely observed. They were: Winona (9011), Yancy (9012), Abe (9015), Dot (9017), Ed (9018), Flo (9019) and Gene (9020). Among them, Yancy will be long remembered by weather forecasters for its erratic track, especially the rare, if not unprecedented, feat of landing in China's Fujian province ***three times in three days*** before finally dissipating inland. Yancy's behaviour after making landfall fully vindicated the Chinese programme of extended IOP's. For many years to come Yancy will be the perfect typhoon for meteorologists to study. In this respect, *SPECTRUM* was extremely fortunate in being able to acquire so much data on a most unusual typhoon.

Looking forward

While the more visible data collection phase of *SPECTRUM* is now completed, the subtle process of transforming the data into applicable knowledge has just begun. As a first step, a quick-look data set is being assembled by RSMC Tokyo Typhoon Centre based on GTS messages and additional data on tapes sent by participating Members. A data catalogue is also to be produced to help interested researchers locate various data sets of a more specialized nature which are held by individual Members. A comprehensive data set embracing the results of *SPECTRUM* and the other experiments will be generated by the US experiment group and will be made available to the *SPECTRUM* research community by late 1991.

With inputs from operational forecasters, the *SPECTRUM* Steering Group met in December 1990 to review the forecasting problems encountered during the IOPs and to identify the associated scientific issues. It is intended that the results of that review will be brought to the attention of researchers in the region. The hope is that researchers from institutions of higher learning will be actively involved, to supplement the contributions from the meteorological services.

As a modest form of motivation, arrangements will be made for the results of their work to be reported in the Typhoon Committee annual reviews and to be presented in a technical conference to be held in China in late 1991. Further opportunities also exist, including the third WMO International Workshop on Tropical Cyclones tentatively scheduled for late 1993. To the extent possible, exchange visits of researchers and attachment of scientists from Typhoon committee Members to advanced centres will also be supported. This is to facilitate the development of scientific ideas and the effective execution of research projects.

All interested parties who see some possibility of applying the data generated by *SPECTRUM* to their ongoing or future research are invited to contact C.Y. Lam at the Royal Observatory with an expression of interest together with an indication of the broad subject area of your intended use of the data. Detailed arrangements can then be made to plan future research.

Mervyn R. Peart

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Storm period variation of rainfall pH: the example of Typhoon Brenda, May, 1989

ABSTRACT

Within storm variation of rainwater pH has been described for Typhoon Brenda which affected Hong Kong in May 1989. Some suggestions have been offered to account for the results. A limited comparison with other "extreme" events is also made.

Introduction

Precipitation which has a pH of less than 5.6 is often referred to as acid rain. There is considerable evidence that much of the rainfall occurring in Hong Kong is acid rain (*e.g.* Tang, 1981; E.P.D., 1986, 1989). The deleterious effects of this upon the environment are reviewed by, for example, Gorham (1976) and Babich (1980).

Investigations into acid rain have, in general, reported values based upon a storm by storm, daily, weekly or longer, sample collection periods (*e.g.* Skartveit, 1981; E.P.A. 1985, McColl *et al.* 1982; Tang *et al.* 1987). In comparison there have been few investigations into within storm variations in precipitation pH. Studies such as Pellet *et al.* (1981) illustrate how useful storm period pH data may be to investigations into acid rain. Storm period sampling may be of considerable value in elucidating the controls upon the pH of precipitation and in the interpretation of stream or river water pH values, especially those obtained during storm hydrographs.

The occurrence of Typhoon Brenda in May, 1989 provided an ideal opportunity to study storm period variation in rainfall pH. The results are presented below.

Typhoon Brenda

Typhoon Brenda began as a tropical depression on May 16th, 1989, over 1000 km east-southeast of Manila in the Pacific Ocean. Landfall was made by Brenda in the Philippines early on May 17th and that evening it entered the South China Sea. Typhoon Brenda affected the South China coastal areas from May 19th to 21st. The typhoon made landfall on the coast of Guangdong some 130 km southwest of Hong Kong. The Royal Observatory (1989) reports that Brenda deposited 322.8 mm on May 20th at the Observatory and that this is the second highest daily rainfall total ever recorded for May. It is also the eighth highest daily total for all months. Other areas of Hong Kong received even more rainfall. For example, 382.5 mm were recorded on May 20th at Sek Kong.

Data Collection

The investigation was based at the Kadoorie Agricultural Research Centre, University of Hong Kong which is located near Sek Kong in the New Territories. The location of Kadoorie is shown in Figure 1.

Rainfall samples were collected at hourly intervals from 0800 hours on May 20th to 0900 hours on May 21st. The samples were collected in a polyethylene container. This simple, open collector, had a diameter of 19 cm and the lip was approximately 25 cm above the ground.

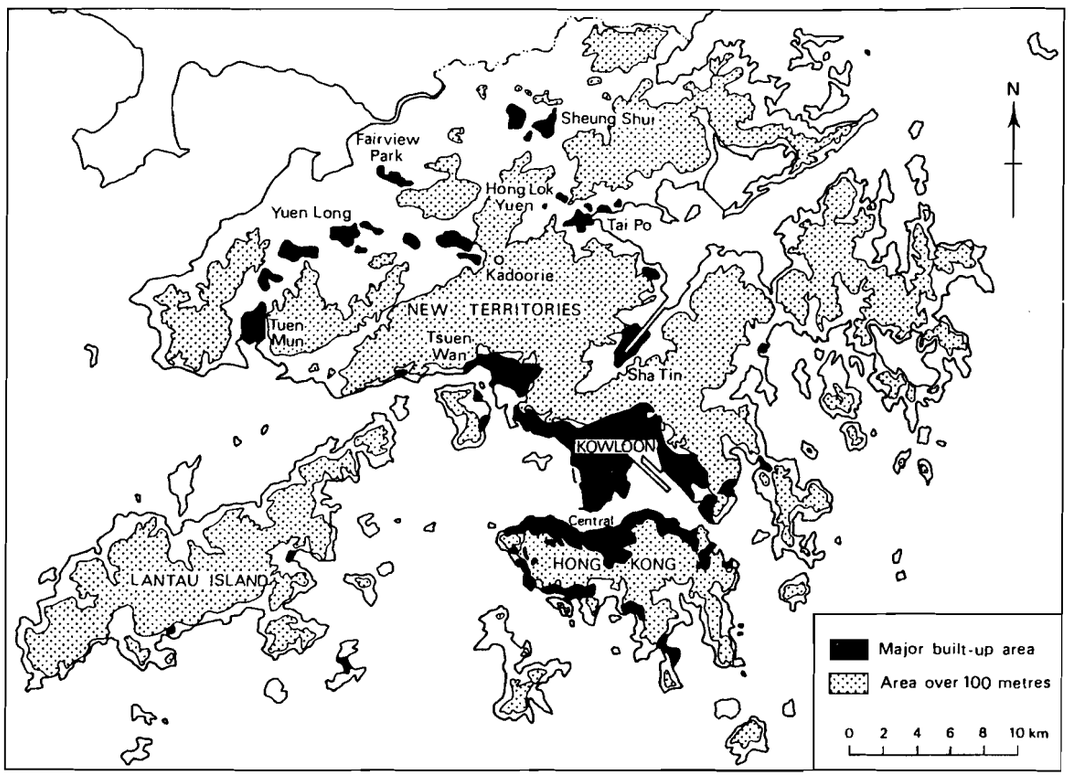

Figure 1 Location of the Kadoorie Agricultural Research Centre in Hong Kong, the data collection site.

A Casella tilting siphon rain gauge fitted with a 24 hour chart was used to record rainfall at Kadoorie. Hourly values of rainfall were abstracted from the chart for May 20th and 21st. No data on wind speed or direction is available at Kadoorie. Therefore, data on wind direction were obtained from the Royal Observatory.

After collection the rainfall samples were taken to the laboratory where pH was determined as soon as possible. The sample pH was determined on the unfiltered sample using a Radiometer meter with a glass electrode. The meter was calibrated using standard buffers of pH 4 and 7.

Results

Figure 2 depicts storm period variation in rainfall pH during typhoon Brenda. For much of the period from 0800 hours on May 20th to 0100 hours on May 21st the pH values are in the range from 5.0 to 5.6. However, from 0200 hours on May 21st rainfall pH becomes more acid with values generally being below pH 5.0. The lowest recorded pH value was 4.71 for the rainfall which occurred between 0500 and 0700 hours on May 21st.

Discussion

Some researchers have found that within a storm event rainfall pH may increase with rainfall amount (*e.g.* Pellet *et al.* 1981). These authors also report that for event based sampling, rainwater pH exhibits a significant positive association with volume of precipitation. Furthermore, the E.P.A. (1985), on the basis of weekly sampling, also report that acidity relates to rainfall amount. They suggest that this may be explained by larger quantities of rainfall washing out more atmospheric acidity. Rainfall amount may, therefore, exert an influence over acidity and pH. However, the E.P.A. (1985) found a poor corre-

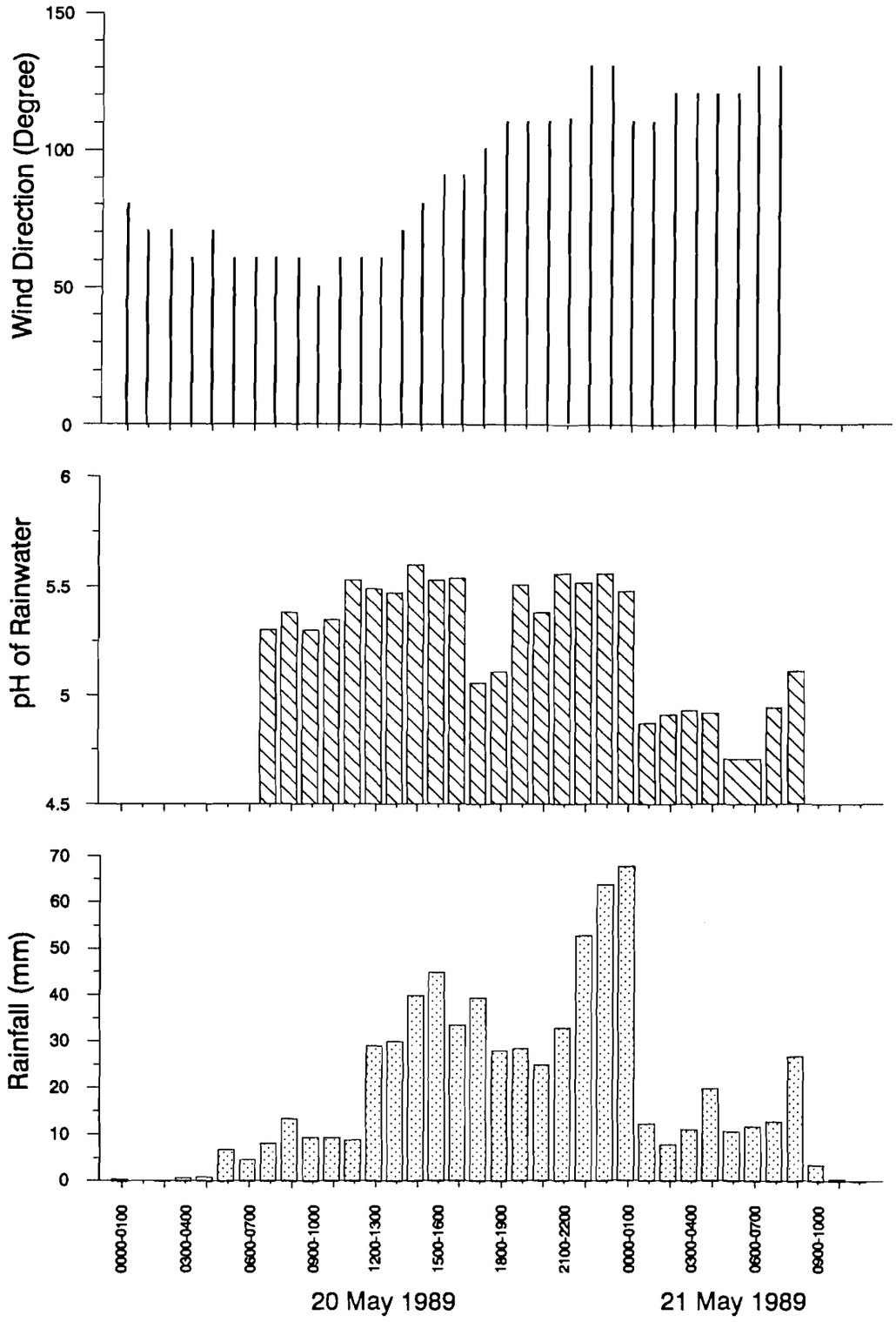

Figure 2 Within storm variation of rainfall pH, precipitation volume and wind direction during Typhoon Brenda.

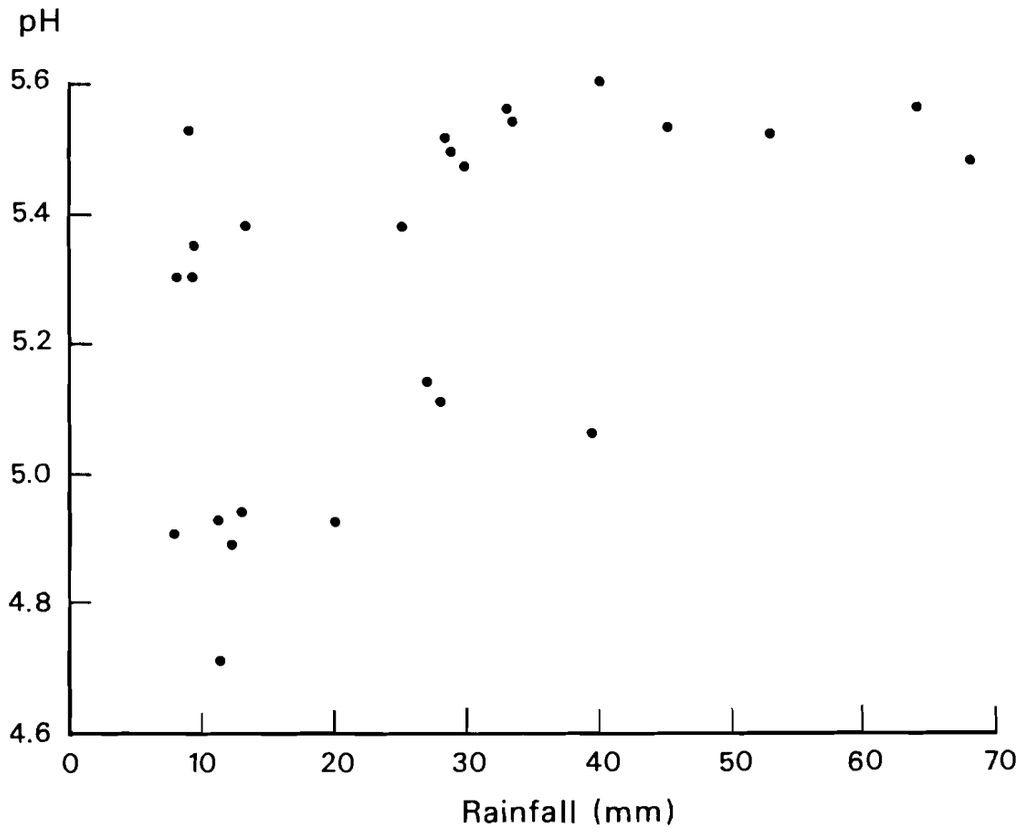

Figure 3 Scattergram of rainfall pH against volume of precipitation for Typhoon Brenda.

lation between rainfall amount and pH. Nevertheless, there is some evidence in Figure 2 that, during a storm, rainwater pH may be influenced by rainfall amount. For example, pH values below 5 are confined to rainfall amounts of less than 20 mm per hour. Comparatively low values of pH were recorded from 0200 hours on May 21st. The change from the comparatively high pH values which prevailed before then on May 21st to the lower levels thereafter coincides with a significant decrease in rainfall amount. It appears that for this storm low values of pH and, therefore, more acidic rainfall are associated with low rainfall rates. However, the low rates of rainfall at the beginning of the rainfall event did not generate low pH values and, moreover, rainfall amount may not be the only factor causing the low pH values at the end of the typhoon.

The scattergram of rainfall pH against precipitation volume presented for the storm in Figure 3 evidences no simple association between the variables for Typhoon Brenda. However, it

does show that for this event low pH values are associated with low rainfall. The scattergraph suggests that other controls over rainfall pH, in addition to rainfall volume, may exist.

Other meteorological factors such as wind direction may control rainwater pH. Figure 2 reveals that wind direction changed during Typhoon Brenda. In the early hours of sampling the wind direction was around 60 degrees. When the prevailing wind was from this direction its approach to the sampling site was from over the North East coastal area of Guangdong Province. By late on May 20th and in the early hours of May 21st the predominant wind direction had changed to become 110 to 130 degrees. This direction of approach opens up Kadoorie to the influence of the urban area of Kowloon and to a lesser extent Tsuen Wan (*see* Figure 1). The urban area may provide an increased source of acidity which may explain the lowering of pH at the end of the storm.

The E.P.A. (1985) report that for their monitoring station at Kwun Tong that rainfall pH related strongly to "*crustal deposition fractions*" in the sample. They suggest that this particulate matter may act to buffer rainwater acidity. This may explain the high pH values in rainwater recorded during the early part of the event, when the wind direction was around 60 degrees. During this part of the storm crustal particulate matter could be obtained from rural areas in NE and E Guangdong and parts of the New Territories. This might act to buffer rainfall pH and could account for the high pH levels associated with the relatively low rainfall amounts at the start of the monitoring period.

With the wind direction change to 110/130 degrees during the evening of May 20th the direction of approach is from the South China Sea. Given that moisture derived from the ocean might be expected to be relatively clean and non acidic it is somewhat surprising to observe that the lowest rain water pH is associated with this wind direction. As suggested earlier one explanation for this low pH might be that the rainfall derives acidity from the urban area on it's way to Kadoorie. A further factor may be that due to the approach from the sea, no crustal derived particulate matter is available to buffer the acidity obtained from the urban area. Unfortunately, no information was collected on the particulate matter content and chemistry of the samples to 1provide additional information for this hypothesis. It should also be remembered that the low rainfall amount at the end of the storm may also be responsible for the lower pH values recorded from 0200 hours onwards on May 21st. Furthermore, in such a complex circulation as exists in a typhoon it must be recognised that other meteorologic factors not considered here may also influence rainwater pH.

The suggestions outlined above to account for the change in rainfall pH during typhoon Brenda indicate that wind direction and meteorological factors in general may be of importance in explaining within storm variation of pH. Other researchers have also noted the importance of wind direction and meteorological conditions as controls upon rainfall pH (*e.g.* Camuffo *et al.* 1984; Skartveit, 1981; Pellet *et al.* 1981).

The study of Pellet *et al.* (1981) is also of interest in that they report results which permit comparison with the present study. They report that rainfall associated with three hurricanes had rainfall pH which ranged from 5.0 to 5.6. They suggest that high rainfall volume is a factor in these high pH values for their study site near Hampton, Virginia. It is interesting to note that their results for samples obtained during a hurricane are similar to these recorded during Typhoon Brenda.

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An analysis of tide gauge and storm surge data in Hong Kong *

ABSTRACT

A maximum rate of future sea level rise of ca. 37 cm/century is predicted from an analysis of tide gauge data obtained over the past 27 years from the North Point (1962-1985) and Quarry Bay (1986-1988) stations in Hong Kong. However, if long term ground-surface settlement of both stations, estimated from surveying data is taken into account, the rate of sea level rise is virtually nil. A possible explanation for this discrepancy between Hong Kong and the global rate of future sea level rise predicted by many overseas workers is the regional subsidence of the Pearl River mouth caused by isostatic responses of sedimentation due to the southerly migration of the Pearl River delta. It is therefore recommended that long term monitoring of ground-surface settlement of all major land reclamations, as well as all operational tide gauge stations in Hong Kong be carried out.

Introduction

A future rise in sea level is of concern to all forms of coastal development by man. In a review by Warwick (1986), global sea level was shown to have risen appreciably over the past century by 10-25 cm. The *best* estimate taking into account the differences in approach of global mean sea level projections by the year 2050 is in the order of 30-70 cm. Sea level rise of this magnitude would have disastrous consequences on coastal lowlands including inundation, salinization, and coastal erosion.

As shown in Figure 1, at the end of 1984, 33 sq. km or 3.2 percent of the original area of Hong Kong have been gained through land reclamation from the sea mainly for the purpose of urban development (Lands Department, 1985). Intertidal areas such as Deep Bay which were reclaimed for agriculture are however excluded from this total. The formation level of reclamations for urban development is kept as low as possible for three main reasons: (1) to reduce the quantities of fill required; (2) to maximize the use of gravity drainage; (3) to minimize the likelihood of flooding during rainstorms in low-lying areas behind seawalls. However, the risk of inundation resulting from a future rise in sea level is increased if the formation level is kept low.

The main objective of this paper is to examine the evidence for a future rise in sea level through tide gauge measurements and the historical record of storm surges associated with typhoons in Hong Kong.

Tide Gauge Measurements

The relative elevation of datums and sea levels in Hong Kong is summarized in Figure 2. Chart Datum (C.D.) is used by the Royal Observatory for all sea level observations while Principal Datum (P.D.) is adopted by the Crown Lands and Survey Office, Hong Kong Government for the

* reprinted with additions and alterations from Yim, W.W.S. (Ed.), 1986: *Future Sea-level Rise and Coastal Development*. Abstracts 5, Geol. Soc. of Hong Kong and Dept. of Geography & Geology, University of Hong Kong, Hong Kong, 18-26.

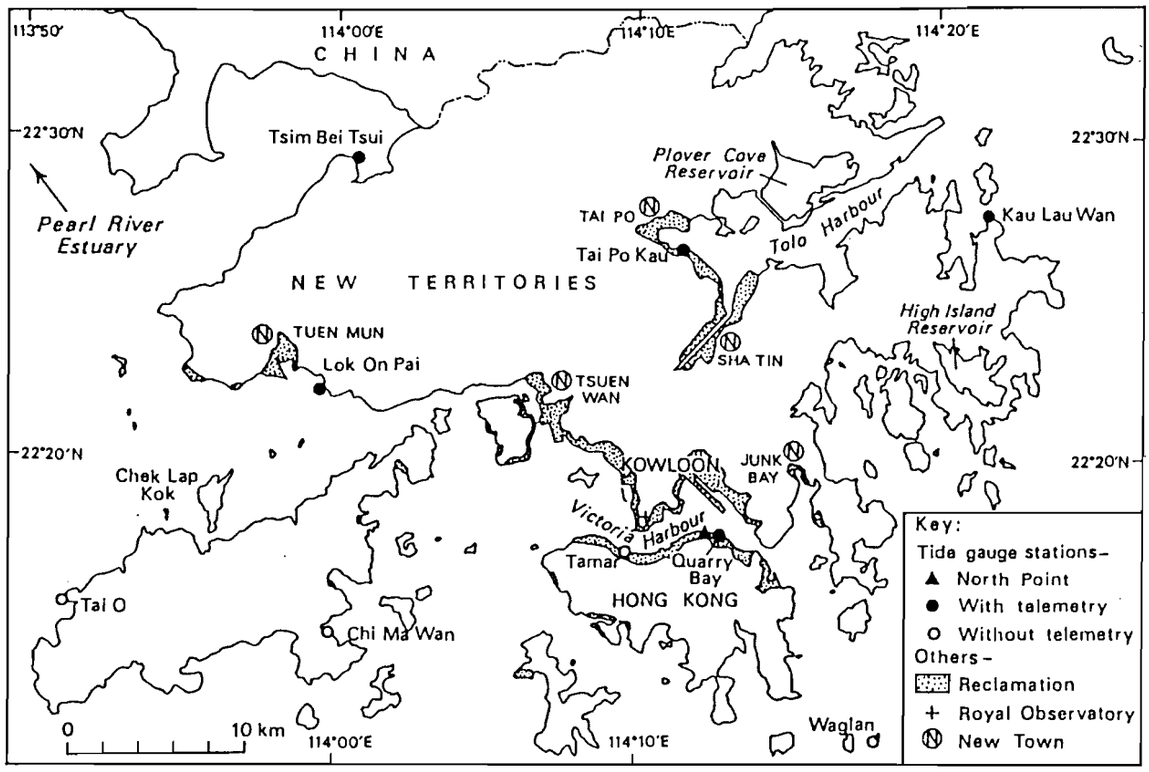

Figure 1 Location map of tide gauge stations, reclamations and New Towns in Hong Kong (after Lands Department, 1985).

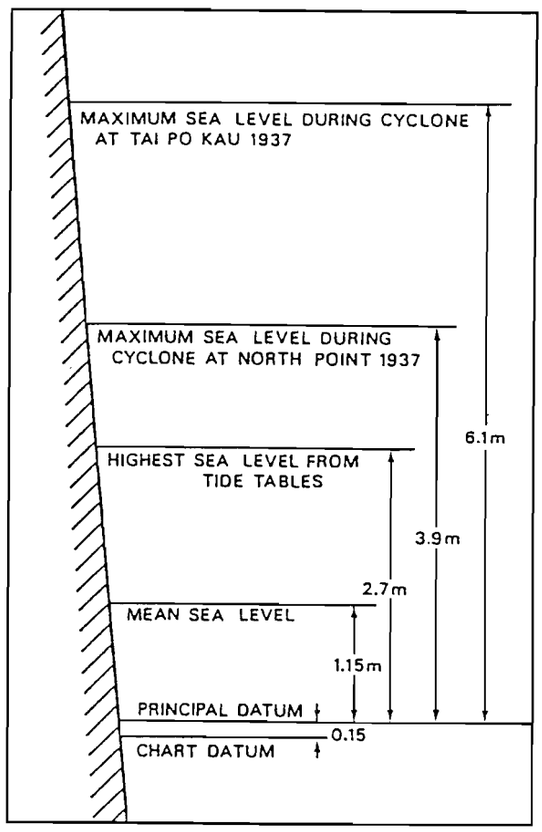

Figure 2 Relative elevations of datums and sea levels in Hong Kong (after Yim, 1986).

design of all civil engineering works. The highest astronomical tide predicted is 2.7 m P.D., but the maximum sea level during typhoons may exceed this elevation by more than 3 m.

The Royal Observatory currently operates nine tide gauge stations in Hong Kong (Cheng, 1986) and these are shown in Figure 1. Hourly readings are obtained and data from some of the stations are telemetered back to the Central Forecasting Office on a real-time basis. However, because of breakdown frequencies and difficulties in maintenance of tide gauge stations located in remote areas, discontinuous records of hourly measurements are common. Out of the nine stations, North Point, Tai Po Kau and to a lesser extent, Chi Ma Wan, possess the most complete record of tide gauge observations. North Point, the oldest tide gauge station was operational for 34 years before it was replaced in 1986 by the Quarry Bay station about half a kilometre to the east.

Since the majority of tide gauge stations in Hong Kong have not been operational for a period of more than twenty years, only three stations with the longest and most continuous record, Chi Ma Wan, North Point and Tai Po Kau, are selected for the present analysis. The periods of tide gauge observations are 1970-1984, 1962-1988 and 1970-1987 respectively. From 1986 onwards, tide gauge data of Quarry Bay are used as a continuation of the data from North Point.

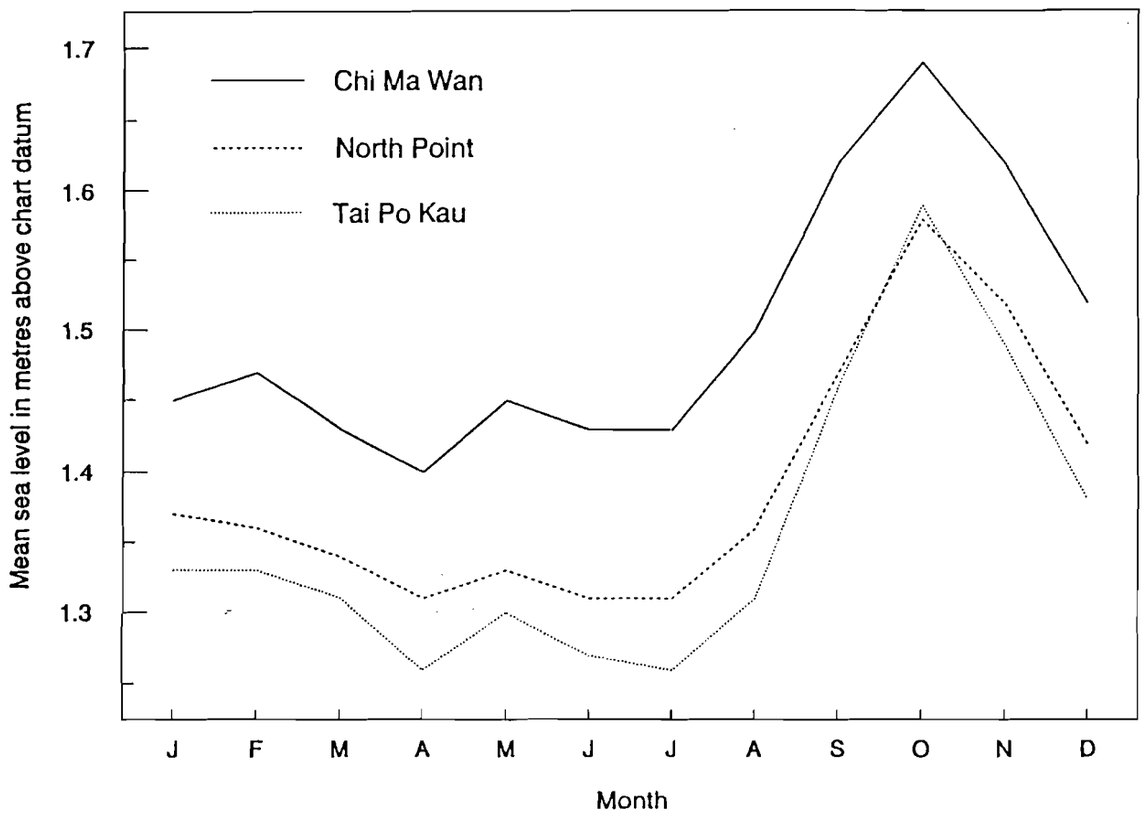

Figure 3 Comparison of 15-year monthly mean sea level above chart datum during 1970-1984 at the Chi Ma Wan, North Point and Tai Po Kau tide gauge stations.

A comparison of 15-year monthly mean sea level during the 1970-1984 period at the three stations is shown in Figure 3. All of them show a similar pattern with the highest monthly mean sea level in October coinciding with the latter part of the typhoon season. Between January and July, the monthly mean sea level is appreciably lower and appears to be related to the dry winter monsoon. Chi Ma Wan is found to show the highest monthly mean sea level followed by Tai Po Kau and North Point. Tai Po Kau shows the greatest range of monthly mean sea level (0.323 m) followed by Chi Ma Wan (0.286 m) and North Point (0.273 m). The difference in range is best explained by the influence of the coastal configuration on the Coriolis force at each station. Because of easterly location and the funnel shaped coastline of Chi Ma Wan, the effect of the Coriolis force is at a maximum and the range is intermediate. North Point located within Victoria Harbour which is open to both east and west has, as expected, the lowest range. Tai Po Kau on the other hand is located in an easterly oriented semi-enclosed harbour and shows the greatest range.

Data for the North Point tide gauge station was chosen for the estimation of the rate of future sea level rise for two main reasons. Firstly, this station appears to be the least influenced by coastal configuration and the Coriolis force, and secondly, it possesses the longest and most continuous tide gauge record. A plot of the annual monthly maximum, mean and minimum sea levels for this station between 1962 and 1988 is presented in Figure 4. The monthly maximum followed by the monthly minimum show the greatest fluctuation which may be explained by the changing intensity of the monsoonal effect. Since the monthly mean shows the smallest fluctuation, it is selected for the estimation of the mean rate sea level rise using a graphical method (Figures 4 and 5). Using this method the mean rate of sea level rise during the 1962-1988 period is about 37 cm/century which, if continuity of the trend is assumed is the future rate of sea level rise. A weak positive correlation of 0.32 exists between the annual mean sea level and annual precipitation of the Royal Observatory station located about 4 km away (Figure 5). Therefore it is possible that at least part of the rise in sea level may be attributed to a local increase in annual precipitation.

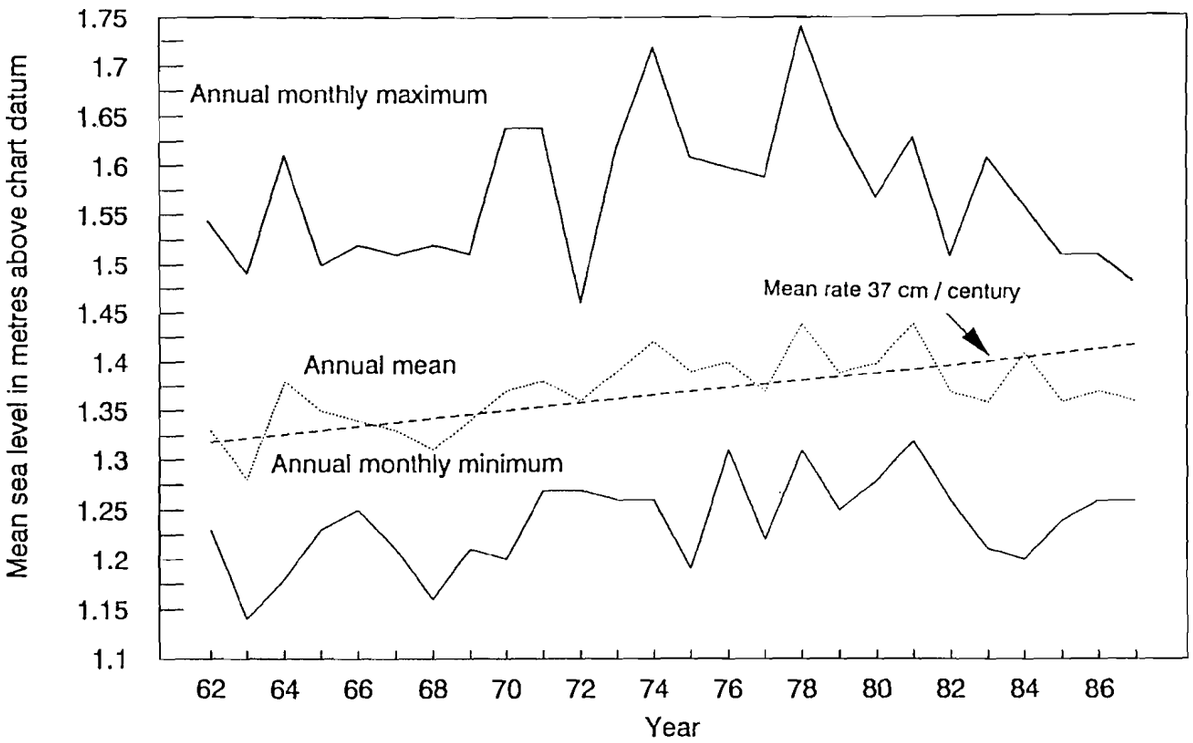

Figure 4 Annual monthly maximum, mean and minimum sea levels in metres above chart datum of the North Point tide gauge station during 1962-1986.

Ground Surface Settlement

Because the North Point tide gauge station is located on a seawall overlying soft marine sediments, long term ground-surface settlement would introduce error into the measurements. The amount of settlement may be estimated from the surveying record kept by the Port Works Division of the Civil Engineering Services Department, Hong Kong Government. Between December 1961 and January 1983, a reference mark for the tide gauge was found to have fallen in elevation from 4.03 to 3.95 m P.D. by levelling with an accuracy of 0.01 m. These results suggest that during the period of tide gauge measurements the overall ground-surface settlement was 8 cm. Based on this, the adjusted mean rate of sea level rise (Figure 5) is virtually nil.

However, since the two bench marks used for checking the elevation of the reference mark at the tide gauge station are also on reclaimed land, at 323 Java Road and 670 King's Road respectively, they are also likely to be affected by long term ground-surface settlement. The assumption that these bench marks will remain unchanged in elevation in time is incorrect because they do not have stable foundations. During 1984, two temporary bench marks were set up at the North Point and Quarry Bay tide gauge stations for surveying purpose. An invest-

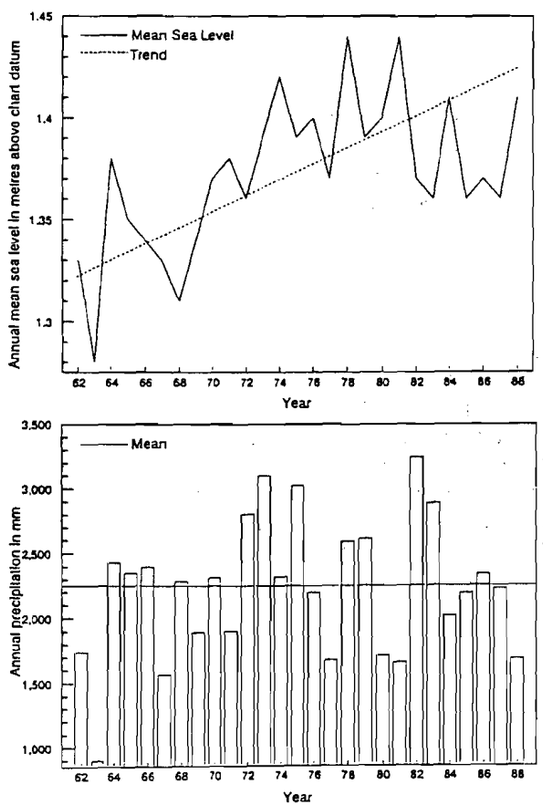

Figure 5 Annual trend of mean sea level in metres above chart datum of the North Point tide gauge station and annual precipitation of the Royal Observatory station during 1962-1988.

Table 1 Meteorological observations and maximum sea level of selected typhoons in Hong Kong since 1937 (based mainly on Chan, 1983).

Tropical cyclone	Year	Maximum gust in knots	Central MSL pressure in hPa	Movement		Maximum sea level in m above chart datum		
				Direction in degrees	Speed in knots	North Point	Tai Po Kau	Chi Ma Wan
Unnamed	1937	130*	949	296	15	4.05	6.25	-
Mary	1960	103	966*	015	12	2.77	-	-
Wanda	1962	140	944*	325	12	3.96	5.03	-
Ruby	1964	122	954*	303	11	3.14	3.54	3.20
Dot	1964	94	973	360	10	2.65	3.23	2.95
Rose	1971	121	982	360	8	2.56	3.00	2.98
Hope	1979	94	950	260	17	2.78	4.33	2.73
Ellen	1983	128	960	305*	8	-	3.06	3.06

* *Estimated*

Table 2 Factors affecting storm surge levels (after Lau, 1980).

Parameters of storm	Coastal parameters	Local factors
central pressure	sea floor topography	river discharges
distance of closest approach	coastline configuration	seiching
translational speed		rainfall runoff
storm path		tidal effects
storm size		wind effects

igation by the Port Works Division revealed that a settlement rate in the order of 5 mm/year is taking place at the seawall and land adjoining the Quarry Bay station between 1984 and 1987 (Port Works Division, *personal communication*). However, since the levelling was also based on the reference bench marks used for the North Point tide gauge station, the true settlement rate is uncertain.

From the above, it is desirable to quantify the amount of long term ground-surface settlement of the tide gauge stations situated on reclaimed land. In order to improve the quality of the tide gauge measurements at the Quarry Bay station, new bench marks located on stable ground would have to be established for future surveying exercises. These new bench marks should be located further inland of the existing ones on structures founded on bedrock. Furthermore, it is desirable to keep a record of any constructional disturbance of their immediate vicinity.

Storm Surge and Sea Levels

A storm surge may be defined as the difference between the observed sea level and the predicted astronomical tide at the same place and time. During a storm surge, the maximum sea level may greatly exceed the predicted astronomical tide and threaten low-lying areas of Hong Kong through marine inundation.

Table 1 provides a summary of meteorological observations and maximum sea level of selected typhoons in Hong Kong since 1937 after Chan (1983). Tai Po Kau is found to show con-

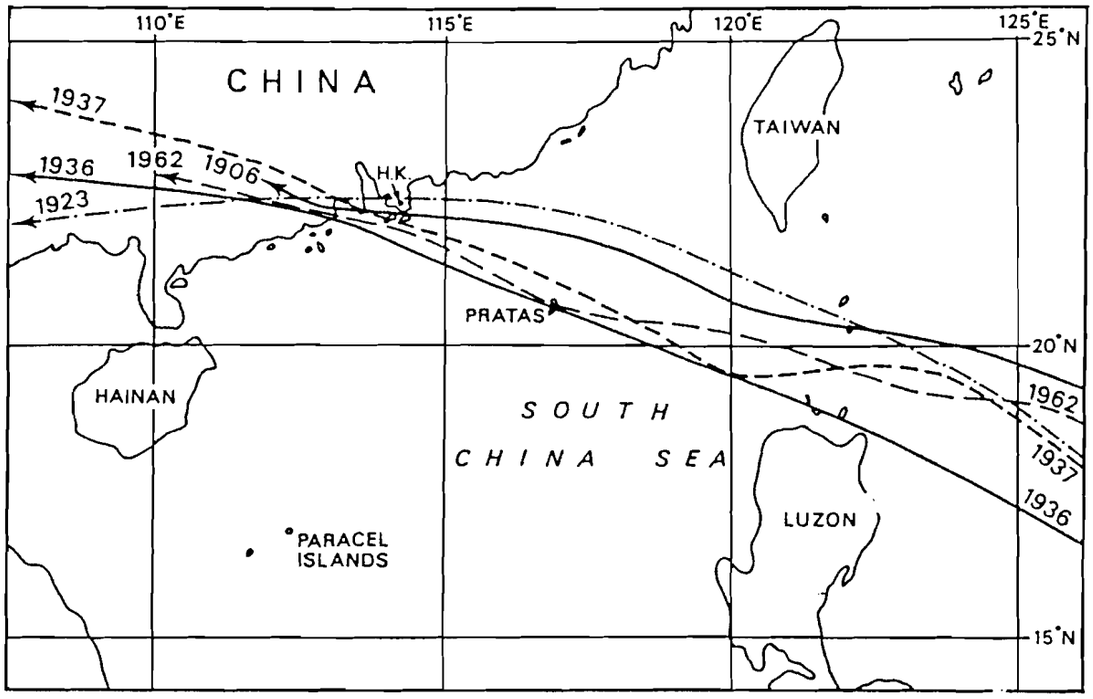

Figure 6 Tropical cyclone tracks responsible for maximum storm surge levels in Hong Kong (after Peterson, 1975).

sistently the highest maximum sea level followed by Chi Ma Wan and North Point. Generally, the highest maximum sea levels found at all stations were associated with the highest maximum gust, the lowest central mean sea level pressure and a west-northwesterly direction of cyclone movement at the greatest speed. Out of the factors influencing storm surge levels (Table 2), coastline configuration, cyclone path and speed appear to be mainly responsible for causing the highest maximum sea level. The maximum sea level of 6.25 m C.D. recorded at Tai Po Kau in 1937 was caused by the semi-enclosed nature of Tolo Harbour which is conducive to extreme seiching. Furthermore, storm surges were found to be the most pronounced when the centre of a typhoon moving westward passes over Hong Kong directly or within 13 km to the south (Watts, 1959). These typhoons have typically almost straight west-north-westerly courses through the strait between Taiwan and Luzon (Figure 6).

A statistical method was used by Peterson (1975) to estimate the return periods of sea levels by combining the effects of storm surges and astronomical tides. However, Chan (1983) considered that interactions between storm surges and astronomical tides may lead to uncertainties in the results. Instead, the method of Gumbel (1954) was adopted by Chan (1983) and applied to data on annual maximum sea levels for estimation of return periods (Table 3). In the case of Tai Po Kau and Chi Ma Wan, because some of the annual maximum sea levels were extracted from monthly maximum hourly sea levels, it is possible that higher sea levels may have occurred. Therefore the return periods for various specified sea levels at Tai Po Kau and Chi Ma Wan are likely to be less than predicted.

Table 3 Return periods of maximum sea level in metres above C.D. estimated using Gumbel's method (after Chan, 1983).

Return Period	Station		
(in yr)	North Point 1950-1981	Tai Po Kau 1962-1981	Chi Ma Wan 1963-1981
10	3.34	4.13	3.40
50	3.71	5.01	3.74
100	3.86	5.39	3.89
200	4.01	5.76	4.03
500	4.22	6.25	4.22
1000	4.37	6.62	4.37

A future sea level rise may threaten Hong Kong in two ways. firstly, a gradual increase in mean sea level, and an increase in the frequency of typhoons associated with storm surges. However, both are difficult to predict given the short meteorological record available. This is further complicated by the appearance of El Nino years during which the global climatic pattern is known to change drastically. For example, El Nino years appear to be associated with a decline in typhoon activity influencing Hong Kong. After the termination of an El Nino episode, their resurgence may be expected.

Conclusions

The mean rate of future sea level rise obtained by extrapolation of annual mean sea level at the North Point tide gauge station during 1962 - 1988 is about 37 cm per century. If ground-surface settlement is taken into account, the mean rate which does not take into consideration the increasing input of carbon dioxide into the atmosphere and the greenhouse effect is virtually nil. However, there are uncertainties in the estimation of the amount and rate of ground-surface settlement because either the tide gauge station or the bench marks used for checking its elevation have not been located on stable ground. As a result of these uncertainties, it is proposed that long term monitoring of ground-surface settlement should be carried out in all major land reclamations in Hong Kong. The information obtained would indirectly benefit storm surge analysis for coastal engineering through an improvement in quality of tide gauge data. If the discrepancy between mean sea level trends found for Hong Kong and other parts of the world is real, then local subsidence of the crust in response to sedimentation of the Pearl River during modern times is a probable explanation. Research work on this topic would be helpful to assist the future coastal development of Hong Kong.

Acknowledgements

I am particularly grateful to the Chief Engineer of the Port Works Division, Civil Engineering Services Department, Hong Kong Government, and the Director, Royal Observatory, Hong Kong for the provision of data. All opinions expressed in this paper are entirely my responsibility. I would also like to thank M.L. Chalmers, D.R. Workman and staff members of the Port Works Division for their constructive criticisms.

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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).

PUBLIC LECTURE SERIES

The Hong Kong Space Museum and the Hong Kong Meteorological Society (HKMetS) have jointly organized a successful series of public lectures in Cantonese planned with a view to improving the meteorological interest and knowledge of Hong Kong citizens. The series ran from 3 June to 8 July 1990 and was well attended. The subjects of the lectures and the guest speakers, all of whom are members of the Society are listed below.

Date: 3 June, 1990

TROPICAL CYCLONES - A CASE FOR THE DEFENCE
by Dr. Johnny Chan, City Polytechnic of Hong Kong

Date: 10 June, 1990

HEAVY RAIN AND LANDSLIDES
by Mr. R.K.S. Chan, Geotechnical Control Office, Hong Kong Government

Date: 17 June, 1990

EL NINO AND UNUSUAL WEATHER
by Mr. W.C. Lee, Royal Observatory Hong Kong

Date: 24 June, 1990

THE THREAT OF THE GREENHOUSE EFFECT
by Dr. C.N. Ng, City Polytechnic of Hong Kong

Date: 1 July, 1990

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

Date: 8 July, 1990

NEW WEATHER EYES AND EARS
by Mr. Edwin S.T. Lai, Royal Observatory, Hong Kong

The popularity of the series has prompted requests from the Hong Kong Space Museum for another series to be run in 1991. The Committee has supported this request and encourages members who are interested in providing the benefits of their experience to the public in this way to contact the Hon. Secretary for details.

HONG KONG IS OUR HOME -

EXHIBITION ON LIVING IN THE GLOBAL GREENHOUSE 90

The Hong Kong Association for the Advancement of Science and Technology (HKAAST) and the Hong Kong Meteorological Society (HKMetS) have jointly organized a successful travelling exhibition planned with a view to improving the environmental awareness of Hong Kong citizens and schoolchildren. The exhibition, which took the form of panelled displays ran from 14 September to 14 October 1990 and was seen by an estimated 100,000 people. Its objective was to

increase the awareness of the general public, and secondary and tertiary students in particular, concerning the problems associated with potential global warming. It also focussed on the action that can be taken to assist humanity to adjust to the reality that what they do as individuals is important and relevant to providing acceptable solutions to the issues which confront society regarding the question of present policy and future climate.

The display materials were a comprehensive range of pictures with bilingual captions describing the natural and man-made causes of climatic changes, the greenhouse effect, depletion of the ozone layer, adverse effects of atmospheric change, as well as international scientific programmes for monitoring the atmosphere. On site presentations were conducted by specially trained University and Polytechnic students at each of the venues.

The Opening Ceremony was held at the Hong Kong Cultural Centre on 14 September, 1990 with the Hon. Graham Barnes, CBE, JP, Secretary for Planning, Environment and Lands, kindly officiating. The Show then remained at the Cultural Centre until 17 September when it moved to NT Heung Yee Kuk Taipo District Secondary School. From there it was transferred to Shun Tak Shopping Mall in Central on 21 September. On 24 September it moved again to CMA Choi Cheung Kok Prevocational School in Tuen Mun and then to Lok Fu Shopping Centre, Lok Fu Estate, Kowloon on 28 September. On 1 October the 6th show opened at TWGHs Wong Fut Nam College, Kowloon Tong. The next show opened on 4 October at City Plaza, Taikoo Shing. From there it was transferred to Cheung Chuk Shan College, North Point on 8 October and finally to New Town Plaza in Shatin on 12 October for the 12th and last show.

As a Society one of the aims of the HKMetS is to help increase people's knowledge of both the atmosphere and the measures that can be taken to reduce the adverse effects of human activity on the climate. Sponsoring the Exhibition was a useful way of promoting our interests in this area. The objective of the event was to try to get across to the general public that our use of energy, our lifestyles and so on, are affecting the atmosphere of the planet as a whole and that it is a serious problem which has global implications. The idea was also promoted that individuals can do their bit to help even if it is only a small contribution to the overall solution of the problem. This was in keeping with the motto "Think Globally Act Locally".

Correspondence

This section is an open forum where members may voice or exchange views or opinions on any subject related to the aims of the Society. Members are encouraged to submit such views to the Editor-in-chief either by mail or by fax with the only limitation being that to be published such communications are of resonable length and are accompanied by the name(s) and membership number(s) of the submitter(s). The Editor-in-chief reserves the right to edit any submission due to space limitations or to conform to established style but will only publish such edited material with the prior agreement of the submitter(s). All opinions expressed in such correspondence are those of the author(s) and do not necessarily reflect those of the Society.

OUT OF THE FRYING PAN .....

As concerned scientists we are all aware that the Earth is threatened by a multitude of manmade hazards from coastal pollution to the depletion of the Antarctic ozone layer. Recently, however, one aspect of these symptoms of ill health, the theory that the build-up of carbon dioxide and other greenhouse gases such as CFC's, methane and nitrogen oxides, will cause global warming has been challenged by a small but vocal group. They contend that the case for warming is weak and based on inadequate computer models.

Not surprisingly, some politicians have coveted this opportunity to caution against undue haste in making decisions. In the U.S. substantial influence has been brought to bear on the Administration. Only recently, for example, President Bush, while not dismissing the potential threat, has emphasized the need for more scientific research to help determine the proper policy response. This slowdown has irritated some, particularly in Western Europe.

In April 1990, a global warming conference was held in Washington, D.C. under the auspices of the White House. A cynic might say that the U.S. Administration hoped to orchestrate a debate on the uncertainties of the greenhouse effect. However, most delegates appeared to agree that global warming is a real, potentially serious threat. There was consensus that unchecked accumulation of greenhouse gases will lead to warming but there was great uncertainty as to when, by how much, and how rapidly it will occur.

This result illustrates clearly the dilemma we face: how to set policy based on uncertain predictions of the future. The most widely accepted estimates of global warming are from 1.5 to 4.5 °C as early as 2050. Yet the computer models used to make the projections may not accurately incorporate such factors as the role of clouds and the capacity of the oceans to absorb heat.

Despite the uncertainties, there is a broad consensus that we should slow down the rate at which we are altering the atmosphere. Yet there is also concern about the economic and political consequences of major shifts in energy use policy. Is it possible to spur energy conservation so long as the scientific evidence is incomplete? Can we buy insurance against global warming without sabotaging the world economy? What do you think and what should be the role of Hong Kong scientists, educators and policymakers in this important issue?

Bill Kyle
Climatologist
University of Hong Kong

Bill Kyle

Department of Geography & Geology

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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 winter 1989-90

Important climatological events

Winter 1989-90, with just over 300 percent of normal rainfall for the three month period, witnessed a return to wetter conditions after six consecutive drier than normal months. Although all three months were wetter than normal February was particularly wet. It was the fifth wettest February on record with 467 percent of normal rainfall. December marked the transition with the first half having clear skies and brilliant sunshine while the latter part was cloudy and rainy. January was generally cloudy and humid, following which February was even wetter and more humid.

Mean daily temperature	**16.6°C**	**(+0.2°C)**
Rainfall (provisional)	**283.4 mm**	**(301 %)**

December

There was a marked contrast between the first half of the month which was clear and sunny and the latter which was cloudy and rainy. Two major rain episodes occurred, one before Christmas and the other before the New Year to give total rainfall 59 percent above average for the month.

For the first seventeen days southern China was dominated by dry continental air. The nights were generally cool but days were mild with long hours of sunshine. During the first week temperatures climbed steadily and the maximum temperature of 23.3 °C recorded on 7th was the highest for the month. Under stable conditions haze occurred several times from 5th to 9th and from 14th to 16th. Fresh easterly winds developed on 17th and the weather deteriorated the following day. From 18th onwards an extensive area of cloud and rain affected southern China. Locally, some light rain fell during the night of 18th and 19th. Active upper air disturbances then moved in from the west bringing rain which became heavier and more persistent in the evening of 22nd and remained until 25th when it eased off in the morning, though the weather remained rather cool. A minimum temperature of 13.1 °C on 24th, repeated on 27th, was the lowest recorded for the month. The 28th was a much brighter day but cloudy weather returned on 29th following the passage of a weak cold front. Light rain occurred on the following two mornings and heavier rain then persisted till the end of the month.

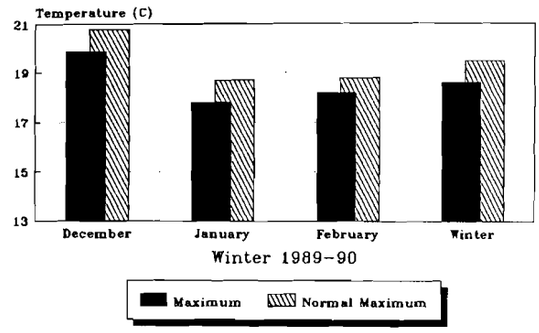
Mean daily temperature	**17.8°C**	**(+0.1°C)**
Rainfall (provisional)	**40.2 mm**	**(159 %)**

January

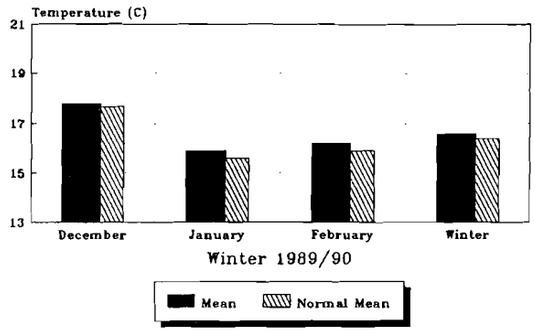
January was generally cloudy and humid with more rain than normal. The monthly mean relative humidity was the eighth highest on record. There were only seven days with no rain recorded at the Royal Observatory during the month and the total rainfall was 77 percent above normal for the month.

The New Year began with light rain on the morning of 1st, with more falling on the morning of 2nd as northerly winds freshened. There was no rain for the next two days but cloudy, cool conditions continued as fresh easter-

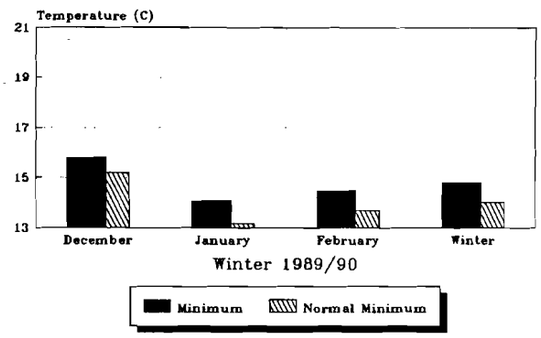
Daily maximum temperature trends



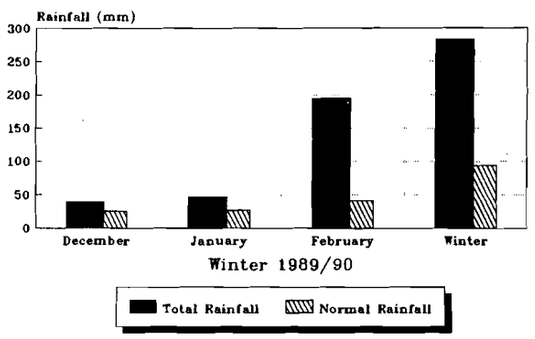
Daily mean temperature trends



Daily minimum temperature trends



Rainfall trends



lies replaced the northerlies. Some drizzle fell on the nights of 5th and 6th although there were periods of sunshine during the day. The clouds broke on 7th and fine weather remained till 12th. Although easterlies occasionally freshened, relatively warm conditions persisted with the maximum of 22.1 °C on 10th being the warmest recorded for the month. At times the freshening easterlies mixed with moist air from the south to give mist and fog offshore. An approaching trough, and the associated clouds, ended the fine spell on 13th. From then on conditions were dominated by the winter monsoon with general cloudiness and light rain occurring mainly at night and in the morning. A cold front passed on 15th bringing strong northerly winds and light rain. This was followed on the 19th by another replenishment bringing more rain and a further lowering of temperatures. A more intense surge occurred early on 22nd causing temperatures to fall below 10 °C for the first time in the winter on the morning of 23rd. The northerlies were replaced by fresh easterlies on 24th. Temperatures rose gradually over the next few days with no further cold surges. A brief lull in the easterlies on Chinese New Year's Day, 27th, resulted in a fine day. This was the only rain free period in a long spell of dull weather. Clouds returned on 28th with rain increasing over the next two days as winds freshened from the east. An intense surge of the winter monsoon crossed the coast on the night of 30th bringing light rain and even colder weather with temperatures at the Royal Observatory dropping by more than 8 °C within 24 hours. By the evening of 31st the temperature had fallen to 8 °C, the lowest for the month and the coldest of the winter to that time.

Mean daily temperature	**15.9°C**	**(+0.3°C)**
Rainfall (provisional)	**47.5 mm**	**(177 %)**

February

February was even wetter and more humid than January, with the month having the sixth highest relative humidity and fifth highest rainfall on record. The monthly rainfall was more than four and a half times the normal February figure.

The intense cold surge at the end of January reached its climax early on 1st when temperatures at the Royal Observatory dropped to a low of 7 °C, the lowest for the month and the coldest of the winter. Temperatures dropped to 4

or 5 °C over the New Territories and reached near freezing over high ground. Easterlies replaced northerlies later on 1st, and some sunny periods on 2nd caused temperatures to climb slowly. A weak replenishment brought them down again on 4th. From 5th to 22nd, a mainly easterly regime prevailed apart from a brief northerly episode on 11th. The weather from 5th to 15th was variable with periods of sunshine and some light rain. Conditions were misty at times when warm, moist air from the Pacific reached coastal areas on the mornings of 9th and 12th. One of the two warmest days of the month occurred on 14th when a maximum of 23.4 °C was recorded. Outbreaks of rain and the first thunder of the year was heard as upper atmospheric disturbances affected the coastal area early on 16th. More thunderstorms developed and the rain got heavier on 17th. Winds dropped on 19th and there was a break from overcast rainy conditions resulting in the same maximum temperature as on 14th. However, freshening easterlies on 20th brought the rain back to persist for two more days. Squalls, associated with thunderstorms, were particularly severe on the night of 22nd. Fog in inshore waters was also common during this period. An intense cold surge terminated the easterly regime on 23rd with the passage of the associated cold front bringing thunderstorms in the afternoon. For the next few days, dull conditions with persistent rain prevailed with temperatures dropping below 10 °C on the mornings of 25th and 26th. Easterlies strengthened again early on 27th but soon gave way to a northerly replenishment later that evening. Although cold, overcast weather continued to the end of the month, the rain eased off.

Mean daily temperature	**16.2°C**	**(+0.3°C)**
Rainfall (provisional)	**195.7 mm**	**(467 %)**

Review of spring 1990

Important climatological events

Spring 1990 was generally cool and dry overall with just over three quarters of the normal rainfall for the three month period. March and May were much drier than normal but this was partly offset by a wet April with rainfall 85 percent above normal. The season started off with a dry and bright March with normal temperatures in marked contrast to the wet and humid first two months of the year. However, April saw the return of gloomy, wet conditions with below normal temperatures which persisted for most of the month. May continued the brighter conditions of late April although the month was considerably cooler and drier than normal with just over one third of normal rainfall and mean daily air temperature 1.3 °C below normal.

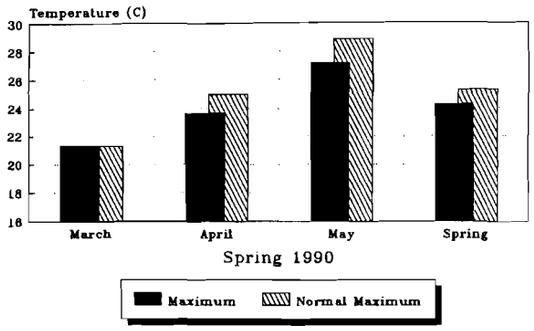
Mean daily temperature	**21.7°C**	**(-0.7°C)**
Rainfall (provisional)	**389.9 mm**	**(79 %)**

March

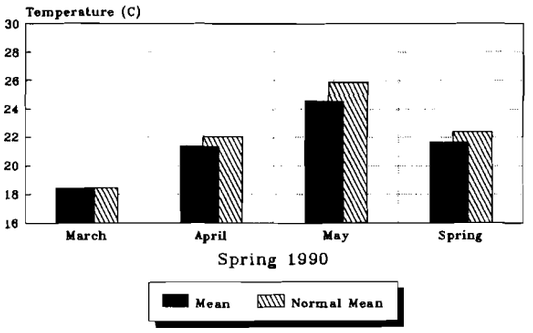
While the first two months of 1990 were wet and humid, March was drier and brighter. The monthly rainfall was 45 percent below normal but bright sunshine was 20 percent above normal due to the persistence of a continental anticyclone over China for most of the month. The monthly mean pressure was the fifth highest recorded for the month reflecting the dominance of the winter monsoon circulation.

The first few days were affected by the persistence of the frontal clouds associated with the cold northerly surge at the end of February leading to drizzle and light rain which became less frequent by 4th. However, the temperature continued to drop as cold air was replenished from the north producing the lowest minimum temperature of 10.8 °C for the month on the morning of 5th. The establishment of dry continental air cleared away the clouds giving sunny periods on 5th and 6th although light rain occurred on the evening of 6th. Winds turned easterly giving mainly fine weather with coastal mist on 7th and 8th. However, as moisture increased in the lower atmosphere cloudier weather returned on 9th although there were long periods of sunshine during the next few days. Visibility deteriorated on the night of 11th with persistent fog offshore and in the harbour in the morning of 12th. Easterlies freshened on 13th producing cloudy weather till 16th when there was some morning rain. Weather then turned generally fine until 22nd except for a brief cloudy spell on 18th. The winter monsoon was relatively inactive for the rest of the month apart from two easterly flows which occurred on 26th and 30th. Prior to the first, weather was warm and humid with bright periods during the day and light drizzle morning and evening. Coastal mist patches were prevalent with the worst visibility in inshore areas on the morning of 24th. The next day was the warmest of the month with a maximum temperature of 27.8 °C. Cloud with light rain returned over the next two days followed by some bright periods on 28th. However, rain clouds and thunderstorms which developed over western Guangdong and drifted east affected the territory giving unsettled weather for the remainder of the month with the heaviest rainfall of 23.4

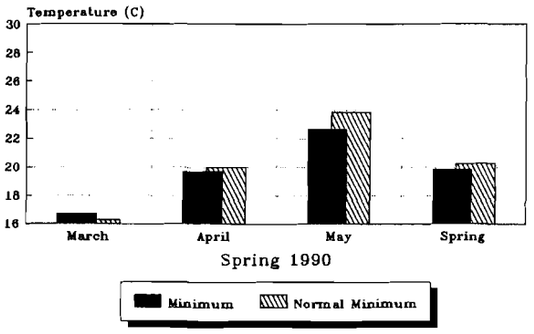
Daily maximum temperature trends



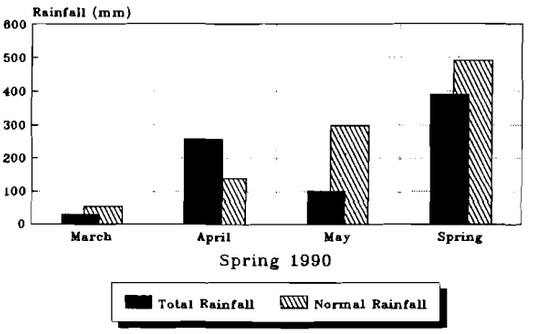
Daily mean temperature trends



Daily minimum temperature trends



Rainfall trends



mm on 30th. Mist and coastal fog persisted during this period.

Mean daily temperature 18.5°C (0.0°C)
Rainfall (provisional) 29.9 mm (55 %)

April

In contrast to March, April was cool, dull and wet for most of the month. The duration of sunshine, 73.8 hours, was the 10th lowest on record and there were only three days when no rainfall was recorded at Royal Observatory. Monthly total rainfall was 85 percent above normal and mean daily air temperature was 0.7 °C below normal.

The first few days of the month were cloudy due to a trough of low pressure over Guangdong. Weather deteriorated on the evening of 3rd as a cold front approached from the north. Its passage brought periods of heavy rain and thunderstorms which eased during 4th although a cool northerly airstream resulted in the lowest minimum temperature of 16.9 °C being recorded on the morning of 5th. Winds turned easterly and moderated giving brighter periods on 6th and 7th. Later on 8th the easterlies freshened and conditions became increasingly unsettled over the next few days as upper air disturbances became active. These brought squally thunderstorms which were most severe on the morning of 11th with gusts of hurricane force being recorded at Waglan Island. Conditions improved on 12th and 13th as a weak northerly airstream affected coastal areas but cloudy conditions returned on 14th with light rain becoming more frequent over the next two days. Strong easterlies early on 17th gave cooler weather but as they moderated encroachment of moist maritime air produced near saturated, extremely humid and misty conditions with persistent sea fog offshore on 19th and 20th. Gusty southwesterlies appeared on 21st and with periods of sunshine appearing the next day, the temperature reached a maximum for the month of 29.3 °C. Easterlies strengthened again on 23rd with outbreaks of rain and thunderstorms that evening. Light, continuous rain continued through the following day becoming heavier on 25th, finally ending on the morning of 26th. As easterlies moderated and a ridge of high pressure became established over southeast China sunny periods developed during the last few days although fog patches returned on the morning of 30th. For the second time in the month the maximum tempera-

ture reached the high of 29.3 °C on that day.

Mean daily temperature	**21.4°C**	**(-0.7°C)**
Rainfall (provisional)	**257.6 mm**	**(185 %)**

May

A wet April was followed by a very dry May with monthly rainfall just over one third of the normal of 298.1 mm. The month was also markedly cool with mean daily air temperature 1.3 °C below normal.

The sunny weather at the end of April continued into early May although visibility was often poor in the mornings and evenings of the first three days. Cloudiness and intermittent light rain occurred on 4th following passage of a weak trough the previous night. The advection of cooler air produced a minimum temperature of 19.9 °C on the morning of 5th, the lowest for the month. After moderation of the northerlies, bright and calm conditions prevailed over the next few days until a moist easterly airstream developed on the night of 8th bringing a return of cloudy conditions. Scattered thunderstorms occurred on the morning of 9th ushering an unsettled period when rain clouds developed from an area of low pressure near Beibu Wan and passed eastwards over Hong Kong. Rain was heaviest on 11th and another outbreak on the night of 12th was accompanied by some thunderstorms. The rain eased on 13th and long sunny periods occurred on 14th but freshening easterlies on that night brought back clouds and some morning and evening drizzle on 15th and 16th. Rain became heavier later on 17th with the passage of a trough, the northerlies behind it bringing relatively cooler weather. During this time Marian developed into a tropical storm near Nansha and intensified to a typhoon while moving north towards Xisha. This necessitated the hoisting of tropical cyclone signals for the first time in 1990 on 17th. Conditions were mainly cloudy with strong offshore winds as Marian turned northeastwards and headed towards Dongsha on 18th. As Marian moved away in the direction of Taiwan, drier air from the continent returned giving sunny, generally fine weather for the next four days. With the passage of a trough early on 24th, the weather turned cloudy and relatively cool. Light rain became nearly continuous from the evening of 25th to the afternoon of 27th. A lull in the easterlies gave a brighter day on 28th but winds freshened again the next day and clouds returned. After some morning rain on 30th, the easterlies subsided and brighter weather returned. Sunny skies on 31st ended the month with a maximum temperature of 30.7 °C, the highest for the month.

Mean daily temperature	**24.6°C**	**(-1.3°C)**
Rainfall (provisional)	**102.4 mm**	**(34 %)**

Review of summer 1990

Important climatological events

Like spring before it summer 1990 was relatively dry with about three quarters of normal rainfall. The season started off with close to normal temperatures and rainfall in June. July was somewhat drier with only 85 percent of normal rain but August was exceptionally dry and hot with just over one third of normal rainfall and record high temperatures for the month.

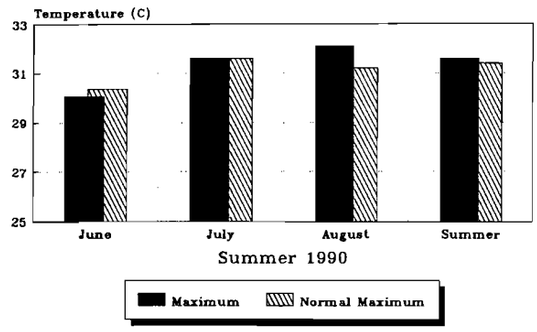
Mean daily temperature	**29.1°C**	**(+0.6°C)**
Rainfall (provisional)	**866.2 mm**	**(75 %)**

June

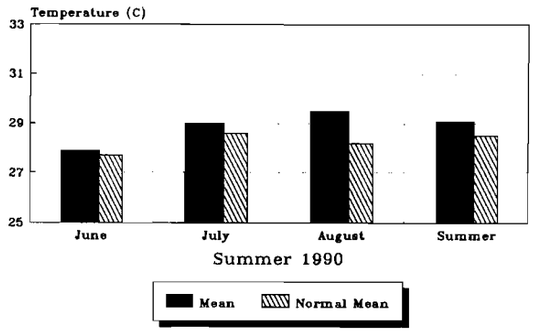
In sharp contrast to May, June was a month characterized by near normal conditions with rainfall only 4 percent above normal and mean daily temperature 0.2 °C above normal. Circulation patterns were also not unusual with most of the rainfall related to the passage of troughs and unstable airstreams associated with tropical cyclones.

The month started with heavy downpours accompanied by squally thunderstorms ahead of and during the passage of a trough. Over 100 mm fell during a 2-hour period around noon on 1st. The rain gradually eased over the next two days but a fresh easterly airstream maintained cloudy conditions and brought slightly cooler weather. The minimum temperature of 23 °C on 3rd was the lowest recorded for the month. After the easterlies moderated on 3rd the weather from 4th to 7th was a mixture of brief sunshine and passing showers. Unsettled weather returned on 8th with occasional thunderstorms associated with the passage of another trough in the evening. Easterlies then freshened and rainy weather with isolated thunderstorms persisted till the morning of 11th. After this the easterlies subsided and the weather improved becoming generally fine for the next four days. The easterlies freshened again on the night of 15th as an area of low pressure west of Luzon developed into tropical depression Nathan. This strengthened and tracked towards Xisha early on 16th before turning northwestward later on 17th before crossing Leizhou Peninsula

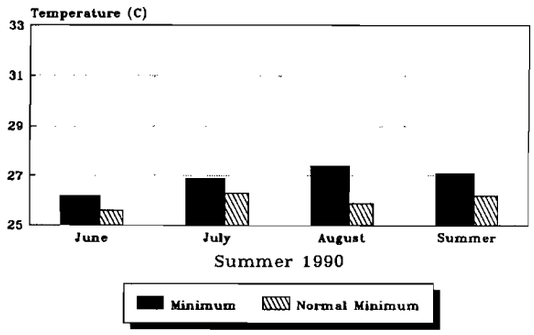
Daily maximum temperature trends



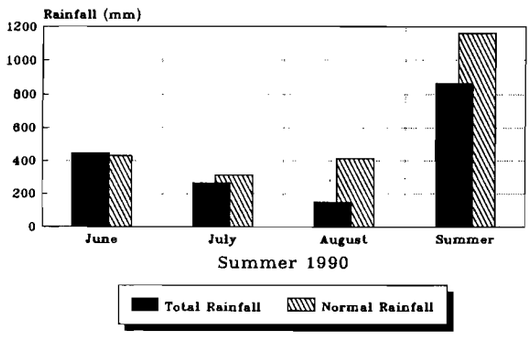
Daily mean temperature trends



Daily minimum temperature trends



Rainfall trends



on 18th. During this time disturbed weather along the periphery of Nathan's circulation brought windy conditions and squally showers. Sunny and hot weather returned on 19th as Nathan dissipated over Guangxi. The fine spell was interrupted by a hazy day on 22nd due to northwesterly winds followed by a cloudy day before fine weather returned on 24th. During the next three days, showers occurred in early morning, the heaviest on 26th being accompanied by thunder and lightning. However, these had little effect on daytime heating and the maximum temperature for the month of 32.9 °C was recorded on 27th. Cloud returned on 29th as Typhoon Percy approached the southeast China coast with an outer rainband bringing some showers that morning. Heavier rain did not occur till the next day as Percy moved further inland and an unstable southwesterly airstream affected coastal areas. Intense rain clouds developed frequently over the Pearl River Estuary and moved in sequence across Hong Kong bringing periods of heavy rain and thunderstorms to end the month.

Mean daily temperature 27.9°C (+0.2°C)
Rainfall (provisional) 448.1 mm (104 %)

July

July was a warm, dry month with both the mean temperature and the mean minimum temperature the seventh highest on record, and a mean relative humidity of 79 percent, the ninth lowest on record. The monthly rainfall total was 15 percent below normal since the weather was basically fine except for showers associated with an unstable westerly airstream in mid-month and periods of rain brought by STS Tasha towards the end of the month.

The month started cloudy in the aftermath of Typhoon Percy but brightened the following day. A ridge of high pressure extended westwards from the Ryuku Islands to produce fine hot weather apart from a some brief showers over the next few days giving rise to a maximum temperature for the month of 33.3 °C on 5th. Heavier showers occurred on the morning of 6th but the fine spell returned and continued to 11th when active southwest monsoon brought increasingly unsettled conditions culminating in showers and thunderstorms in the morning and evening of 12th. This unsettled spell continued to 15th when a ridge extending from the Pacific reinstated the fine weather for a further five days. Coastal

areas then came under the influence of an easterly airstream from 21st to 23rd as an area of low pressure moved west across the South China Sea. Although weather remained basically fine some thunderstorms occurred during this time. The easterlies moderated and after heavy rain early on 24th the weather improved to give sunny, rainfree days on 25th and 26th before intense daytime heating produced thunderstorms again on 27th. The last few days were dominated by the presence of tropical storm Tasha to the east of Hong Kong. Weather became increasingly cloudy on 28th and 29th and as Tasha approached the coast of eastern Guangdong on 30th the weather deteriorated further with periods of squally rain and strong northerly winds. After landfall on 31st the winds moderated but squally, thundery showers persisted during which the monthly minimum temperature of 23.8 °C was recorded.

Mean daily temperature 29.0°C (+0.4°C)
Rainfall (provisional) 268.0 mm (85 %)

August

August was exceptional in being the hottest and driest on record in Hong Kong. On 18th the temperature reached 36.1 °C, equalling the high set 90 years ago. The mean temperature of 31.9 °C, and minimum temperature of 30.1 °C recorded on that day made it the hottest on record. The monthly mean temperature of 29.5 °C and monthly mean minimum temperature of 27.4 °C are also record highs and the monthly mean maximum temperature of 32.1 °C is the second highest ever recorded. The monthly mean relative humidity of 75 percent is also the lowest ever recorded for August. With such a hot, dry month rainfall was also low, the total of 150.1 mm being the tenth lowest on record and only 36 percent of normal for the month.

The month started cloudy and unsettled in the moist southwesterly airstream in the wake of STS Tasha. The first three days registered 100 mm of rain, two thirds of the total for the month. Over the next three days fine, hot weather gradually became established to set the pattern for the month. There were outbreaks of thunderstorm activity on 11th and 13th and passage of a major squall line caused the temperature to drop to a low of 25 °C for the month on 16th. For the next six days Hong Kong came under the influence of Typhoon Yancy in the western North Pacific Ocean. This initially brought relatively dry continental air in the northwesterly circulation which affected the territory. Conditions were fine during the initial part of this period being hot and hazy on the 17th. The temperature stayed above 30 °C that night and as heat built up the following day all was set for the record breaking conditions of 18th. With the approach of Yancy to the coast of Fujian between 20th and 22nd cloudy weather spread across the coastal areas. These broke on 23rd although as the remains of Yancy moved west along the coast some light rain occurred that evening. Fine weather then prevailed for three days apart from light showers on the morning of 25th. For the next four days the weather was influenced by Typhoon Becky which moved westwards across the South China Sea. Clouds increased as the easterlies freshened on 27th. Winds increased the next day bringing squally showers. Both eased off on 29th as Becky passed to the south of Hainan before dissipating over Vietnam. Fine conditions then returned for the remainder of the month.

Mean daily temperature 29.5°C (+1.3°C)
Rainfall (provisional) 150.1 mm (36 %)

Review of autumn 1990

Important climatological events

After a dry summer, autumn 1990 was 15 percent wetter than normal, although this was principally due to a wet September since October was drier than normal and November rainfall was near normal. The season was also warmer than normal with November being considerably warmer despite a high incidence of winter monsoon circulation.

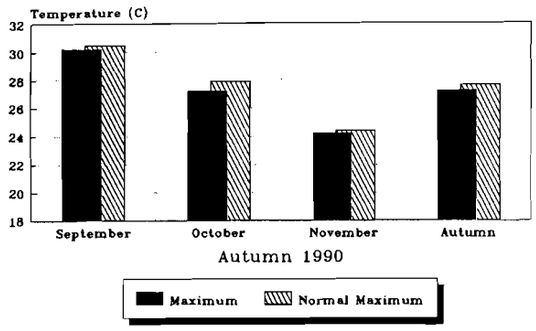
Mean daily temperature 25.0°C (+0.4°C)
Rainfall (provisional) 547.5 mm (115 %)

September

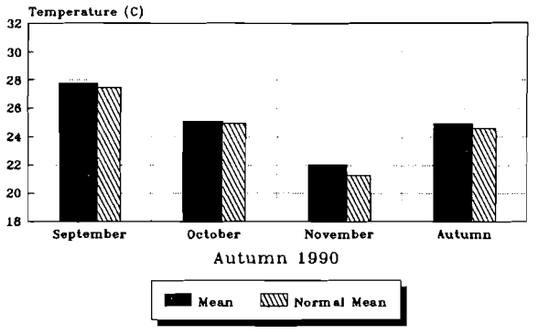
Overall, September was warm but relatively cloudy and wet with monthly rainfall being 28 percent above normal. Over half of the month's rain could be attributed to the passage of Typhoon Dot across southern China.

The first two days were sunny and very hot with the passage of Typhoon Abe over eastern China bringing a continental air mass to the south China coastal areas. On 2nd relative humidity dropped below 50 percent and temperature reached a maximum of 33.8 °C for the month. Winds then turned easterly giving some light showers but generally fine weather persisted till an outbreak of thunderstorms in the afternoon of 6th. Hong Kong then came under the influence of Typhoon Dot which crossed Taiwan on the

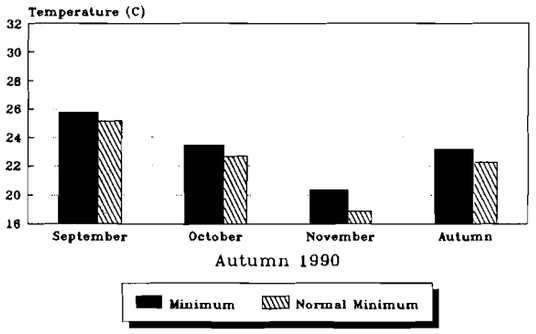
Daily maximum temperature trends



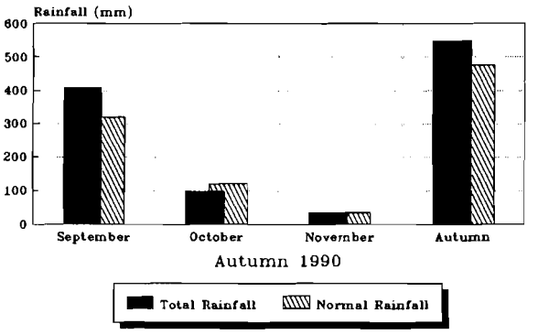
Daily mean temperature trends



Daily minimum temperature trends



Rainfall trends



night of 7th and passed over the Taiwan Strait the next day making landfall near Xiamen. Weather was fine on 7th but the typhoon brought torrential rainfall over the next five days as it degenerated over southern China. Rainfall exceeded 230 mm over the 5-day period from 8th to 12th, being heaviest on 10th when over 100 mm were recorded. Conditions improved on 13th with generally fine weather persisting over the next five days except for squally showers on 15th as Typhoon Ed passed to the south of Hong Kong. However, as Ed turned on a more northwestward track towards northern Vietnam one if its outer rainbands reached the coast on 19th bringing nearly 100 mm of rain on that day. Thunderstorms also occurred and the temperature fell to 23.9 °C, the lowest recorded for the month. The next five days were characterized by periods of sunshine interspersed with isolated light showers. A low pressure trough passed on the evening of 24th giving heavier rain and more thunderstorms the next day. The next three days were a combination of cloud, light showers and sunny intervals before the last two days ended the month with brilliantly fine weather.

Mean daily temperature 27.8°C (+0.3°C)
Rainfall (provisional) 409.9 mm (128 %)

October

October was about 10 percent sunnier than normal and also had the seventh highest mean monthly atmospheric pressure on record both reflecting the dominance of the continental anticyclone in influencing the circulation. Rainfall was 17 percent below normal with most falling in the early part of the month.

The maximum temperature recorded on 1st, 30 °C, the highest of the month, reflected the fine weather which continued from the end of September. Easterly winds brought light rain early on 2nd and cloudy weather for the next two days. With the landfall and dissipation of TD Ira over Vietnam moisture and rain spread northwards to give two outbreaks of rain on 4th and 5th. These produced about 95 mm in total with latter also being accompanied by thunderstorms. A dry northerly airstream arrived on the night of 5th and for the next seven days the daily minimum relative humidity was below 60 percent. During this time fine weather prevailed apart from some drizzle early on 9th. With a return of moister conditions, cloud increased on 13th. However, with a persistent ridge of high pressure over eastern China, a fresh easterly airstream

gave fine weather until 20th with only occasional light drizzle at night. Cloud returned on 21st to be followed by three more fine days with the weather warming up ahead of an approaching cold front. This front crossed the south China coast in the evening of 24th, bringing some rain during the night. Cool northerlies with cloud brought the temperature down to a low of 19.7 °C on the morning of 26th, the lowest for the month. Winds turned easterly on 27th and apart from some light drizzle at night the weather remained fine for the rest of the month.

Mean daily temperature 25.1°C (+0.1°C)
Rainfall (provisional) 100.7 mm (83 %)

November

November was generally windy and cloudy although, apart from an intense cold surge near the end of the month, the winter monsoon did not bring low temperatures. The mean daily temperature was 0.8 °C above normal and the monthly mean minimum temperature of 20.4 °C was the fifth highest on record. Rainfall was only slightly above normal.

The fine weather which ended October continued for the first two days of November but cloud and rain moved in from western Guangdong on 3rd. With easterlies freshening cloudy conditions with persistent light rain, mainly in the evenings, lasted for the next six days. A cold front crossed the coast in the morning of 9th giving strong northerly winds and some light rain and lowering the temperature several degrees. The dry northerly air stream resulted in the clouds thinning and sunny periods developing on 10th and 11th. For the next week windy conditions persisted as the northeast monsoon was enhanced by the presence of tropical cyclones in the South China Sea. First, TS Nell formed north of Nansha and moved towards Vietnam. During this time the weather remained fine, though windy, but as Typhoon Mike entered the South China Sea clouds developed and rain fell in the afternoon of 15th. On 16th, as Mike turned north towards Hainan winds strengthened to reach an hourly mean maximum offshore of 80 km h^{-1} in the morning of 17th. During this time there was nearly continuous light rain until warmer conditions and fine weather returned on 19th. Temperatures reached a high of 27.7 °C on 20th, the maximum recorded for the month, but this warm spell was brief as a cold front arrived that evening. Fresh northerly winds and clouds returned on 21st but the latter soon cleared to begin another fine spell on 22nd although winds did not moderate till 23rd. The presence of Typhoons Owen and Page in the western North Pacific continued to induce continental air flow leading to a progressive fall in temperatures from 26th. A major outbreak of cold air reached the coast in the evening of 30th bringing strong gusty winds, hourly mean speeds of 90 km h^{-1} being recorded at Tate's Cairn. Although the weather remained fine, both the relative humidity and temperature dropped sharply ending the month with a low temperature of 15.6 °C at midnight on 30th.

Mean daily temperature 22.1°C (+0.8°C)
Rainfall (provisional) 36.9 mm (106 %)

Meeting Reviews

Special Topics Lecture Series

Venue: Royal Observatory, Hong Kong

Date: 7 July, 1989

Two lectures were presented by distinguished visitors who were in Hong Kong in connection with the International Conference on East Asia and Western Pacific Meteorology and Climate held from 6-8 July and hosted by the Royal Observatory, Hong Kong and the Centre of Asian Studies, University of Hong Kong.

Subject: Polar Orbiting Meteorological Satellite Data Receiving and Processing System in China

Dr. Xu Jianmin, Director of the Satellite Meteorological Centre, State Meteorological Administration, People's Republic of China, talked to members about the Chinese meteorological satellite system, providing very interesting information on the polar orbiting satellite, FY1, the ground station and data processing centre, the data receiving and processing system, and the products available.

Subject: Atmospheric Numerical Modelling for Weather Prediction

Prof. T.N. Krishnamurti of Florida State University, provided members with the benefit of his expertise in numerical modelling by talking about models and their limitations in weather prediction, particularly in tropical conditions.

Venue: Royal Observatory, Hong Kong

Date: 31 August, 1989

Subject: Acid Rain in North America

Dr. James R. Mahoney, Director of the National Acid Precipitation Assessment Program (NAPAP), U.S.A. talked to members about the problems associated with acid rain in North America and the work of NAPAP.

Research Forum 1

Venue: University of Hong Kong

Date: 30 September, 1989

Subject: Modelling and Measurement in Meteorology

A successful inaugural research forum was held at the University of Hong Kong, Rayson Huang Theatre on the theme "Modelling and measurement in meteorology". The Opening Ceremony and Welcome Address was presided over by Chairman of the Society, Mr. Patrick Sham, who expressed the hope that this would be the first of many to come since one of the most important functions of the Society was to enable members to share and discuss ideas concerning meteorology and related fields of endeavour.

The first session, on *MODELLING STUDIES*, was chaired by Dr. Steve Hsu of the Department of Geography, The Chinese University of Hong Kong.

Two papers were delivered as listed.

STOCHASTIC MODELLING OF WIND AND TEMPERATURE

by Dr. Fred Hickernell, Dept. of Mathematics, Hong Kong Baptist College

MODELLING TYPHOON SURGES IN TOLO HARBOUR, HONG KONG

by Dr. Y.C. Hon, Department of Mathematics, Hong Kong Baptist College

Following a break for refreshments the second session, on *MEASUREMENT STUDIES*, was chaired by Dr. Bill Kyle of the Department of Geography & Geology, University of Hong Kong.

Two papers were delivered as listed.

WAVE CHARACTERISTICS IN BEI BU WAN

by Dr. Y.S. Li, Department of Civil & Structural Engineering, Hong Kong Polytechnic

THE COLLECTION AND ANALYSIS OF WAVE DATA AT THE ROYAL OBSERVATORY, HONG KONG

by Mr. T.S. Cheng, Royal Observatory, Hong Kong

The forum concluded with an OPEN DISCUSSION in which the views of those attending were sought concerning topics for future research forums and an appeal made for any member with suggestions to contact the Executive Committee. The general consensus was favourable for continuance of such forums and it was tentatively planned to hold a second in the spring of 1990.

Special Topics Lecture Series

Venue: Royal Observatory, Hong Kong

Date: 2 October, 1989

Subject: Global Tropospheric Experiment (GTE) and the Pacific Exploratory Mission (PEM)

Dr. Robert J. McNeal, Director of the Atmospheric Chemistry Program of the National Aeronautics and Space Administration (NASA), U.S.A. talked to members about NASA's GTE and PEM projects which aim to ask questions and test hypotheses on the role of aerosols and tropospheric gases in influencing climate. Dr. McNeal has vast field experience in the various GTE programs, including the Amazon Boundary Layer Experiment (ABLE) and gave members the benefit of that as well as his expert knowledge in the latest techniques for measuring trace gases and on tropospheric processes. He also described the various components of the PEM , the different airborne experiments being planned and their objectives in relation to the study of atmospheric chemistry in the Pacific Basin, an area considered ideal for conducting such experiments.

Venue: Royal Observatory, Hong Kong

Date: 6 January, 1990

Subject: Coastal Protection Against Sea Waves

Prof. Patrick Holmes, Professor of Hydraulics in the Department of Civil Engineering and Dean of the City and Guilds College, Imperial College of Science, Technology and Medicine, U.K. talked to members about his experiences in coastal protection. He is an international consultant on coastal and offshore engineering problems involving wave action and his expert knowledge of wave processes and their engineering applications exposed members to a very interesting aspect of the relationships among meteorological and coastal processes, and architectural and engineering design principles. In addition he presented some interesting scenarios related to future coastal protection in the light of potential sea level change associated with greenhouse warming.

Annual Meeting 1990

Venue: City Polytechnic of Hong Kong

Date: 23 March, 1990

Thirty two members and two observers participated in the Annual Meeting of the Society held at 6:00 pm on Friday, 23 March, 1990 at the City Polytechnic of Hong Kong, Tat Chee Avenue, Kowloon. The outgoing Chairman, Mr. Patrick Sham, welcomed them and thanked the members of the 1989-90 Executive Committee for their hard work and the members of the Society for their support in the inaugural year of the Society.

He then presented his annual report for 1989-90 which highlighted the following points. At the end of February, 1990 membership of the Society stood at 131, comprising 82 Fellows, 43 Associate Members, 4 Student Members and 2 Corresponding Members. During the year a logo for the Society had been designed and adopted and ties bearing the logo had been made and were available for purchase. During the year various activities of scientific and technological interest to

members and their guests were organized. These included five lectures in the Special Topics Lecture Series given by distinguished visitors, two Research Forums, and a Visit to the Weather Station and Climatology Laboratory of the Chinese University of Hong Kong intended to stimulate the interest of secondary school students. Several members of the Society were invited to present papers at the International Conference on East Asia and Western Pacific Meteorology Weather and Climate, the lectures of which were open to members.

A review of intended activities in 1990-91 was then presented. In summary he concluded that the Society has had moderate success in its first year of existence with the growth in membership in such a short time being better than expected and he hoped that member's interest in and support for the Society would grow in the coming year.

The Hon. Treasurer, Dr. Steve Hsu, then presented the audited accounts of the Society for the year, which were adopted unanimously.

Election of Office Bearers of the Society, and appointment of the Honorary Legal Advisor and Honorary Auditor resulted in the following:

Chairman	Mr. P. Sham
Vice-Chairman	Dr. W.J. Kyle
Hon. Secretary	Mr. Y.K. Chan
Hon. Treasurer	Dr. S.I. Hsu
Committee	Dr. J.C.L. Chan
	Dr. F. Hickernell
	Dr. Y.S. Li
Hon. Legal Advisor	Ms. Venus Choy
Hon. Auditor	Mr. J.C.T. Wu

The major item of business was to consider the proposed amendments to the constitution submitted by the Executive Committee. These were: to incorporate Institutional Membership in the Society; and to extend Student Membership in the Society to secondary school students studying in Form 5 or above. After discussion and amendments to the original submission, both amendments were adopted and will be in force subject to the approval of the Registrar of Societies.

The meeting agreed to continue waiver of the Entry Fee for all those who submit their application to join the Society in 1990 in order to encourage a growth in membership. The following annual subscriptions for the year were also adopted:

HK$150	for Fellow
HK$100	for Associate Member
HK$ 50	for Student Member
US$ 20	for Corresponding Member
HK$500	for Institutional Member

Research Forum 2

Venue: Hong Kong Baptist College

Date: 24 March, 1990

Subject: Natural Disaster Reduction - the Role of Meteorology and Hydrology

A successful second research forum was held at the Hong Kong Baptist College with the theme being chosen to coincide with that of World Meteorological Day which was to introduce the 1990's as the Decade for Natural Disaster Reduction. The Society was honoured to have Dr. the Hon. Daniel Tse, OBE, JP, the President of Hong Kong Baptist College present at the Opening Ceremony and to deliver the Welcome Address.

The first session, on *A GLOBAL OVERVIEW*, was chaired by Dr. Fred Hickernell of the Department of Mathematics, Hong Kong Baptist College.

Three papers were delivered as listed.

INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION - HOW METEOROLOGICAL & HYDROLOGICAL SERVICES CAN HELP

by Mr. Patrick Sham, Royal Observatory, Hong Kong

MONITORING HAZARDS IN THE NATURAL ENVIRONMENT USING METEOROLOGICAL SATELLITES

by Dr. Bill Kyle, Department of Geography and Geology, University of Hong Kong

THE IMPACT OF HOURLY GMS (GEOSTATIONARY METEOROLOGICAL SATELLITE) IMAGERY ON OPERATIONAL WEATHER FORECASTING

by Mr. Edwin Lai, Royal Observatory, Hong Kong

Following a break for refreshments during which there was a Computer Display of *METEOROLOGICAL IMAGE VISUALIZATION* the second session, on *NATURAL HAZARD REDUCTION IN HONG KONG*, was chaired by Dr. Bill Kyle of the Department of Geography & Geology, University of Hong Kong.

Two papers were delivered as listed.

REDUCING THE THREAT OF FUTURE SEA LEVEL RISE

by Mr. W.S. Yim, Department of Geography and Geology, University of Hong Kong

THE USE OF METEOROLOGICAL RADAR IN OPERATIONAL FORECASTING

by Ms. Hilda Lam, Royal Observatory, Hong Kong

Popular Meteorological Lecture Series No. 1

Venue: Hong Kong Space Museum

During the month of June and early July the Society co-sponsored with the Hong Kong Space Museum a successful inaugural series of popular lectures on meteorological subjects in Cantonese. The subjects and speakers are listed below.

Date: 3 June, 1990

TROPICAL CYCLONES - A CASE FOR THE DEFENCE
by Dr. Johnny Chan, City Polytechnic of Hong Kong

Date: 10 June, 1990

HEAVY RAIN AND LANDSLIDES
by Mr. R.K.S. Chan, Geotechnical Control Office, Hong Kong Government

Date: 17 June, 1990

EL NINO AND UNUSUAL WEATHER
by Mr. W.C. Lee, Royal Observatory Hong Kong

Date: 24 June, 1990

THE THREAT OF THE GREENHOUSE EFFECT
by Dr. C.N. Ng, City Polytechnic of Hong Kong

Date: 1 July, 1990

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

Date: 8 July, 1990

NEW WEATHER EYES AND EARS
by Mr. Edwin S.T. Lai, Royal Observatory, Hong Kong

Special Topics Lecture Series

Venue: Royal Observatory, Hong Kong

Date: 20 September, 1990

Subject: Visibility Study Programme in Connection with the Navajo Generating Station

Dr. Jerry L. Shapiro, of the Natonal Acid Precipitation Assessment Program (NAPAP), U.S.A. talked to members about his work in connection with the air pollution and atmospheric visibility impacts of the Navajo electric power generating plant in U.S.A.

Research Forum 3

Venue: City Polytechnic of Hong Kong

Date: 10 November, 1990

Subject: Engineering Applications of Atmospheric Modelling

A third research forum was held at the City Polytechnic of Hong Kong with the theme being chosen to complement the 4th World Congress of Council on Tall Buildings and Urban Habitat, sponsored by Hong Kong Institution of Engineers and held from 5 - 9 November in Hong Kong. The Society was honoured to have Dr. A.G. Davenport, Director of The Boundary Layer Wind Tunnel Laboratory, The University of

Western Ontario, London, Canada present to deliver the Opening Address.

The first session was chaired by Dr. Y.S. Li of the Department of Civil & Structural Engineering, Hong Kong Polytechnic.

Two papers were delivered as listed.

COMPUTATION OF STRATIFIED FLOW PAST A HILL

by Dr. S.C. Kot, Department of Mechanical Engineering, University of Hong Kong

CORRELATION STUDIES ON RAINFALL INTENSITIES AND SLOPE FAILURES

by Dr. J. Premchitt, Geotechnical Control Office, Civil Engineering Services Department, Hong Kong Government

Following a break for refreshments the second session was chaired by Dr. S.C. Kot of the Department of Mechanical Engineering, University of Hong Kong.

Three papers were delivered as listed.

THE EFFECT OF CLIMATE CHANGE ON BUILDING DESIGN

by Prof. A.P. Jeary, Department of Building and Construction, City Polytechnic of Hong Kong

APPLICATION OF ENVIRONMENTAL DATA IN MARINE WORKS DESIGN

by Mr. J. Gabay, Port Works Division, Civil Engineering Services Department, Hong Kong Government

THE ROLE OF METEOROLOGICAL DATA IN WATER QUALITY MODELLING

by Dr. J.H.W. Lee, Department of Civil and Structural Engineering, University of Hong Kong

Calendar of Coming Events

This section is intended for the publication of forthcoming events organized by the Society or by other organizations with similar aims. If members wish to notify the Society of any such events they should mail or fax such information to the Editor-in-chief along with their name(s) and membership number(s).

1991

New Orleans, USA, **January 13 - 18**

71st American Meteorological Society Annual Meeting.

1st American Meteorological Society Symposium on *"Winter Storms"*.

2nd American Meteorological Society Symposium on *"Global Change Studies"*.

7th American Meteorological Society Symposium on *"Meteorological Observations and Instrumentation"*.

7th American Meteorological Society International Conference on *"Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology"*.

7th American Meteorological Society Joint Conference with Air and Waste Management Association on *"Applications of Air Pollution Meteorology"*.

Male, Maldives, **January 29 - February 4**

18th Session, WMO/ESCAP Panel on Tropical Cyclones.

Hong Kong, **March**

Hong Kong Meteorological Society and Hong Kong Space Museum *Popular Meteorological Lecture Series*.

London, England, **March 22**

Royal Meteorological Society Meeting at The Royal Society on *"Computers in Meteorology & Oceanography"*.

Hong Kong, **April**

2nd Hong Kong Meteorological Society Annual Meeting.

Trieste, Italy, **April 8 - 12**

World Meteorological Organization Technical Conference on *"Long-range Weather Forecasting Research"*.

Cairo, Egypt, **April 21 - 27**

International Symposium on *"Geophysical Hazards in Developing Countries and their Environmental Impacts"*.

London, England, **April 24**

Association of British Climatologists Meeting on *"Current Climatological Research in United Kingdom"*.

Geneva, Switzerland, **May 1 - 26**

11th World Meteorological Congress.

Miami, USA, **May 6 - 10**

5th American Meteorological Society Conference on *"Meteorology and Oceanography of the Coastal Zone"*.

19th American Meteorological Society Conference on *"Hurricanes and Tropical Meteorology"*.

Hong Kong, **June**

Hong Kong Meteorological Society and Hong Kong Science Museum *Popular Meteorological Lecture Series*.

Paris, France, **June 24 - 28**

4th International Conference on *"Aviation Weather Systems"*.
25th International Conference on *"Radar Meteorology"*.

Keele, England, **August 5 - 7**

Royal Meteorological Society Summer Meeting at the University of Keele on *"Weather Forecasting - Science and Art"*.

Vienna, Austria, **August 11 - 24**

20th International Union of Geodesy and Geopphysics General Assembly.

Salt Lake City, USA, **September 10 - 13**

7th American Meteorological Society Conference on *"Applied Climatology"*.

10th American Meteorological Society Conference on *"Biometeorology and Aerobiology"*.

20th American Meteorological Society Conference on *"Agricultural and Forest Meteorology"*.

HONG KONG METEOROLOGICAL SOCIETY

Office Bearers:	Mr. P. Sham	(Chairman)
(1990-1991)	Dr. W.J. Kyle	(Vice Chairman)
	Mr. Y.K. Chan	(Hon. Secretary)
	Dr. S.S.I. Hsu	(Hon. Treasurer)
	Dr. J.C.L. Chan	
	Dr. F.J. Hickernell	
	Dr. Y.S. Li	

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All references should be arranged in alphabetical and chronological order. In the text, in brackets, author's surname(s) followed by the date; in the reference list at the end, the author's surname(s) and initials followed by the date and the title of the work. If a book, this should be followed by the publisher's name, place of publication and number of pages; or, if a journal article, by the title of the periodical, volume and page numbers.

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香港氣象學會

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HONG KONG METEOROLOGICAL SOCIETY

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