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# Some aspects of the summer monsoon in South-East Asia May to September 1986

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**In this report the rainfall pattern, onset, low-frequency oscillations and tropical storm activities over the South China Sea during the 1986 northern hemisphere summer monsoon are documented. On the whole, South-East Asia experienced below normal rainfall from May to September 1986. The onset date of the monsoon over South-East Asia was found to fall within the range of onset dates determined by Orgill (1967). There was a distinct 20 to 40 day oscillation in the surface pressure, upper wind and rainfall in South-East Asia during the monsoon. This oscillation was found to be related to the active and break cycle of the monsoon. Tropical storm/typhoon occurrence was below average for all the months except for May.**

## Introduction

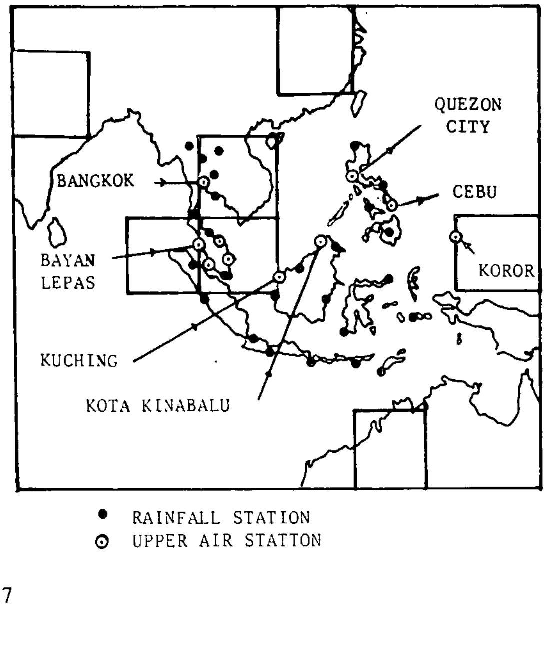
This report discusses some aspects of the 1986 northern hemisphere summer monsoon *(May to September) in South-East Asia, which coincides with the area of responsibility of the Activity Centre located in the Malaysian Meteorological Service for the WMO Long-term East Asian Winter Monsoon project. Since the paper by Kingston et al. (1987) has discussed the large-scale circulation anomalies that occurred in the tropical region in Asia and Australia, this report will review only the following features of the 1986 summer monsoon in South-East Asia:

- Rainfall pattern
- Onset of summer monsoon in the northern hemisphere
- Synoptic features associated with the onset of summer monsoon
- Low-frequency oscillation
- Tropical storms and typhoons in the South China Sea.

The data base used in this report is derived from plotted and manually-analysed surface and upper air charts prepared in the Activity Centre. Rainfall data from Indonesia, Singapore and Thailand were extracted from the 'Monthly Climatic Data for the World', National Climatic Data Center, USA. Malaysian rainfall data (23 stations) and upper air data (four stations) were extracted from monthly abstracts published by Malaysian Meteorological Service.

Surface pressure data from stations located in seven different 10° × 10° latitude boxes distributed in Asia and Australia were used to examine the low-frequency oscillation of the monsoon. The distribution of these areas is shown in Fig. 1.

**Fig. 1** **Rainfall and upper air stations in Indonesia, Malaysia, Philippines, Thailand and west Pacific and 10°×10° latitude-longitude boxes in Asia and Australia from where average surface pressure was used to examine the low-frequency oscillation.**




*The northern hemisphere summer monsoon in South-East Asia is locally known as the southwest monsoon since the prevailing winds at low-levels are southwesterlies.

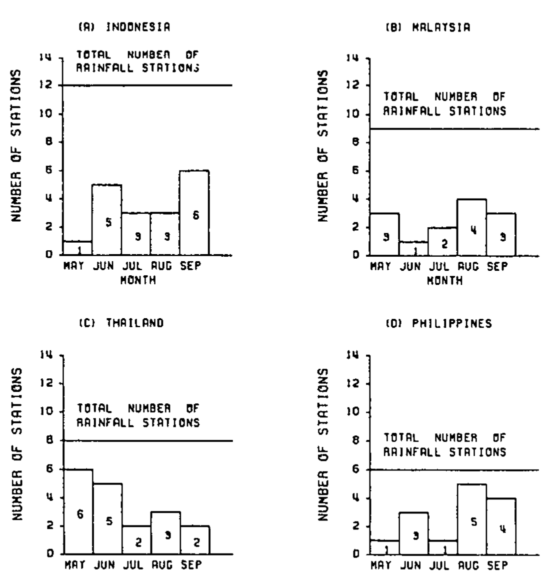
Also shown are the locations of the rainfall stations in South-East Asia and the seven upper air stations in South-East Asia. Upper air data from the seven upper air stations are used in examining the onset of the monsoon, whereas data from four of the stations in Peninsular Malaysia are used in examining the low-frequency oscillation.

## Rainfall pattern

Figure 2 depicts the total number of stations which recorded above normal monthly rainfall from May to September 1986 in four regions, namely, (A) Indonesia, (B) Malaysia, (C) Thailand and (D) Philippines.

It can be seen that during May 1986, most of the stations in Indonesia, Malaysia and Philippines experienced below normal rainfall. The Philippines was the only country which became wetter from August to September 1986 with most of the stations reporting above normal rainfall. The deficiency in rainfall may be attributed to the low-level southerly and easterly anomalies over most parts of South-East Asia shown in the circulation anomaly charts of Kingston et al. (1987). These anomalies indicate a weakening of the low-level monsoon trough. The increase in wetness over the Philippines in August and September may be related to the cyclonic anomaly in the low level shown also by Kingston et al. (1987).

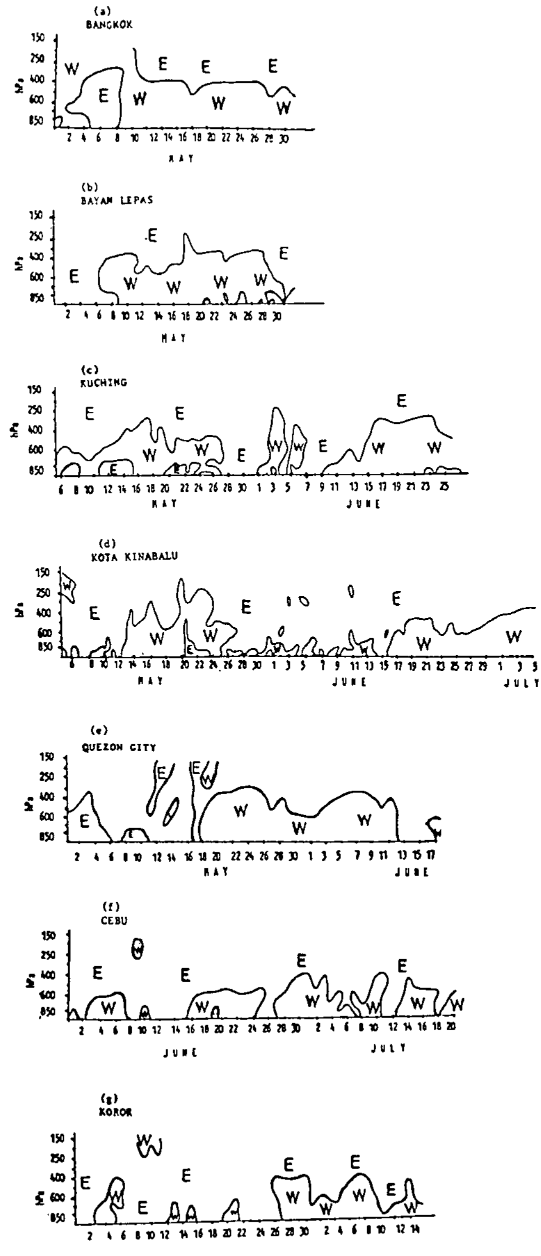
**Fig. 2 Number of stations reporting above-normal monthly rainfall in (A) Indonesia (B) Malaysia (C) Thailand and (D) Philippines May to September 1986.**




## Onset of 1986 northern hemisphere summer monsoon in South-East Asia

The onset of the summer monsoon in South-East Asia is defined as the time at which the 850 hPa and 700 hPa u-components of the winds become

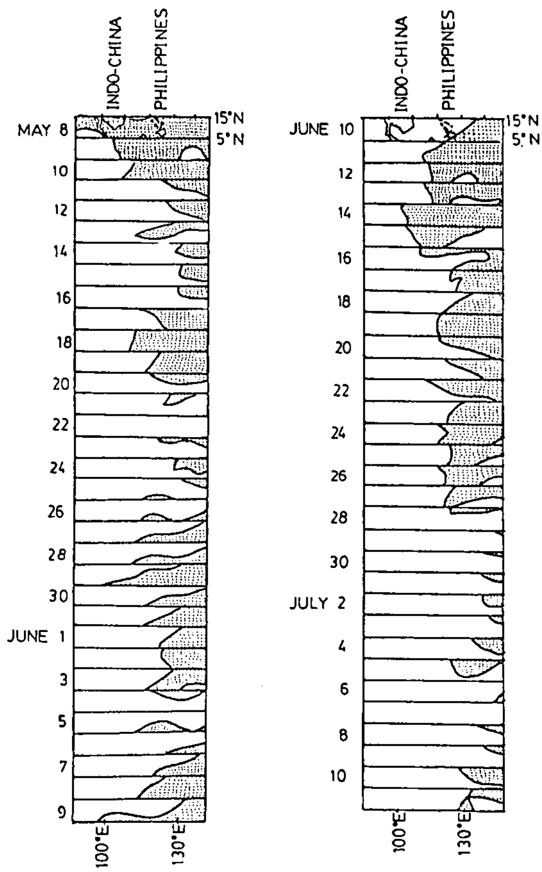
**Fig. 3 Vertical-time cross-section of upper winds of (a) Bangkok (b) Bayan Lepas (c) Kuching (d) Kota Kinabalu (e) Quezon City (f) Cebu and (g) Koror. E – east-winds, W – west-winds.**



positive and stay positive for at least 20 consecutive days during the one-month period from the onset date.

Figure 3 shows the vertical-time cross-section of upper winds at Bangkok in Thailand, Bayan Lepas in Peninsular Malaysia, Kuching in northwestern Borneo, Kota Kinabalu in northeastern Borneo, Quezon City in northern Philippines, Cebu in central Philippines and Koror in the west Pacific (see Fig. 1). Based on the definition of the onset, it can be seen clearly in Fig. 3 that the onset date at Bangkok and Bayan Lepas is 9 May. Orgill (1967) determined the mean date of the onset of summer monsoon in South-East Asia to be 17 May with a range of one month. Although the onset date of 9 May for Peninsular Malaysia and Indo-China is eight days earlier compared to Orgill's mean date, it still falls within the range of the onset dates determined by Orgill. For stations located east of Bangkok and Bayan Lepas the onset dates are much later. They are 19 May, 10 June, 16 June, 27 June and 27 June for Quezon City, Kuching, Kota Kinabalu, Cebu and Koror respectively. The onset did not advance northward with time, which is the case for India and China. Nevertheless the eastward advancement is not as simple as indicated by these dates. Figure 4 is the Hovmoller diagram of 850 hPa east and west-winds in South-East Asia and west Pacific from 8 May through 10 July 1986. It clearly depicts the intrusion of easterly winds to the South China Sea from the Pacific. This appears to be the main cause for the interruption of the steady advancement of the westerly winds towards the east.

**Fig. 4 Hovmoller diagram of 850 hPa east and west-winds over South-East Asia and west Pacific (latitude 5° to 15° north) from 8 May through 10 July 1986. Stipled areas are east-winds.**




## Synoptic features associated with the onset of the summer monsoon

At the low level (Fig. 5 (a)), the most distinct synoptic features in South-East Asia just before the onset are:

(a) the development of a near-equatorial trough which ran across Peninsular Malaysia to the Bay of Bengal from West Pacific;

(b) a near-equatorial vortex moved across Peninsular Malaysia, intensified over Bay of Bengal and finally recurved to landfall over western Thailand/southern Burma.

The intensification of a low over Bay of Bengal was found by Orgill (1967) to be one of the prerequisite conditions for the onset of summer monsoon over South-East Asia.

At the upper level (Fig. 5(b)), the most significant feature in the large-scale circulation from 8 May 1986 (just before the onset in South-East Asia) through 27 June (onset over west Pacific) is the northward displacement of the subtropical ridge from South-East Asia to southern China.

## Low-frequency oscillation

Numerous studies on the oscillation of the Indian summer monsoon have been conducted in the past. Cheang et al. (1981) conducted a preliminary investigation on the oscillation of the summer monsoon in South-East Asia during May to September 1979 and found distinct oscillations around (a) three to six days, (b) seven to eight days and (c) 30 days in Malaysian rainfall and the surface pressure in South-East Asia and west Pacific. In this report we examine only the mode of oscillation in the low frequency band of 20 to 40 days which has been found by Yasunari (1979), Cheang et al. (1981) and Krishnamurti and Subrahmanyam (1982) to be associated with the active and break cycle of the monsoon and also the northward movement of the monsoon convec-

**Fig. 5(a) 850 hPa positions of near-equatorial trough axes and centres of cyclonic vortices on 3, 5, 7, 9 May 1986. Dashed lines represent trough axis. Crosses are the centres of the cyclonic vortices. Numbers beside the trough axes are the dates in May 1986.**

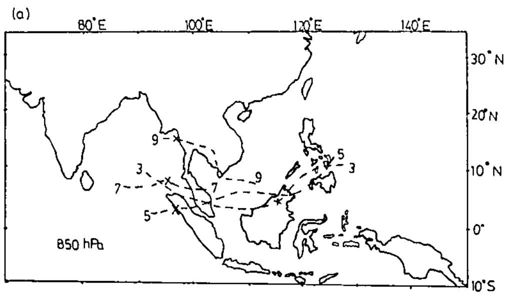
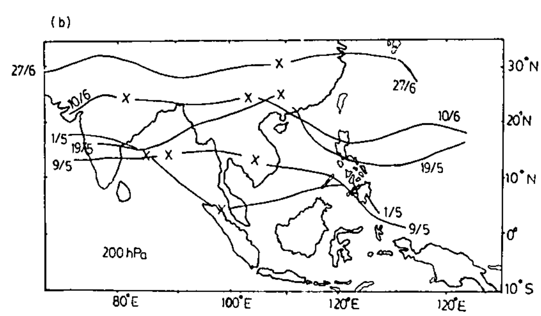
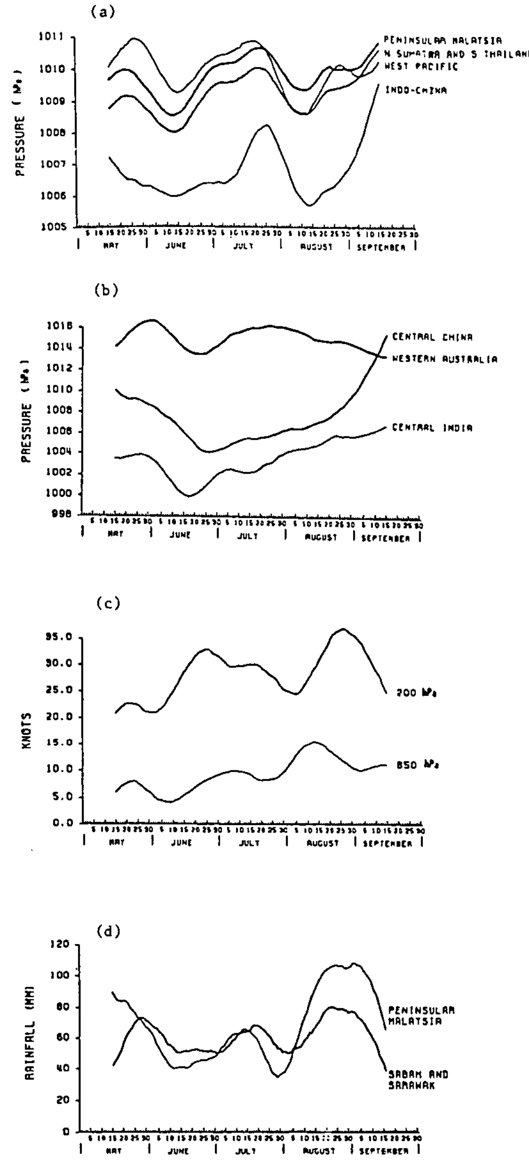



**Fig. 5(b) 200 hPa positions of ridge axes and centres of anticyclone on 1, 9, 19 May, 10 and 27 June 1986. Full lines represent the ridge axes. Crosses are the centres of the anticyclones.**



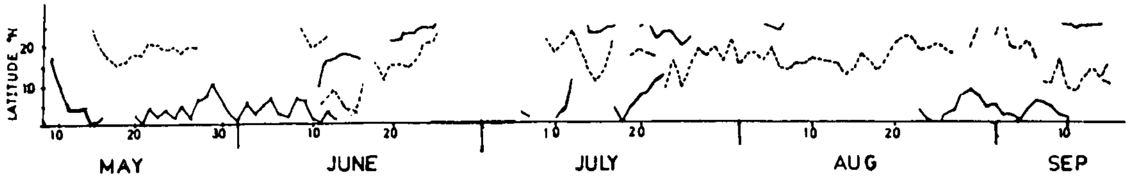

tive activity. To examine the 20 to 40 day oscillation, a Gaussian low-pass filter was applied to the time-series of (a) average surface pressure in Peninsular Malaysia, Sumatra/south Thailand, Indochina, west Pacific, India, China and Australia, (b) 850 hPa and 200 hPa average east and west-winds over Malaysia and (c) total daily rainfall in Peninsular Malaysia, Sabah and Sarawak. These filtered series are arranged in order from top to bottom in Fig. 6. Filtered series of average pressure over China, India and Australia are included in the figure for the purpose of comparison. The figure clearly depicts that there are two major cycles of oscillations in the surface pressure in South-East Asia and equatorial west Pacific with two distinct minima, one around 12 June and the other around 12 August. There are two minor cycles with minima occurring around early July and early September 1986. The filtered series for South-East Asia and equatorial west Pacific are almost in phase. The filtered series of average surface pressure in India has only one major minimum around 17 June (about five days

**Fig. 6 Low-pass filtered time-series of:**
**(a) average surface pressure over Peninsular Malaysia, northern Sumatra/southern Thailand, west Pacific and Indo-China;**
**(b) central China, Western Australia and central India;**
**(c) average 850 hPa and 200 hPa east and west-winds over Peninsular Malaysia. At 850 hPa westerly winds are taken as positive whereas easterly winds are taken as positive at 200 hPa;**
**(d) total daily rainfall in Peninsular Malaysia, Sabah and Sarawak.**




lag behind the minimum in South-East Asia), and a minor minimum around 14 July (about six days lag behind the minor minimum in South-East

**Fig. 7 Latitude-time cross-section of 850 hPa trough (dashed) and ridge (full) positions 0° and 25°N from 9 May through 14 September 1986.**




Asia). In the 1986 Indian summer monsoon, from around 15 July 1986, the filtered series of average surface pressure had an increasing trend. This may indicate an early weakening of the 1986 Indian summer monsoon. Kingston et al. (1987) also found that the MSL pressure and the monsoon westerlies over India during June, July, August 1986 were higher and weaker than normal respectively. Comparing the filtered series of surface pressure of Malaysia with that of Australia, it can be observed that there is no simple relationship. Comparing the surface pressure of Malaysia with that of China, we can see one major minimum in China occurred around 27 June, 14 days behind that in Malaysia. There is no 20 to 40 day oscillation in the China filtered series except for the seasonal increasing trend after 27 June.

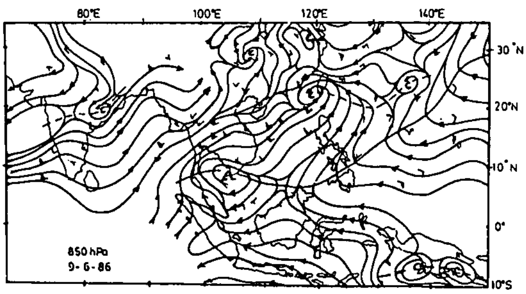
To illustrate the synoptic events that are associated with the fluctuations which have been described above, a latitude-time cross-section of the trough and ridge positions along 115°E (over South China Sea) from 9 May through 14 September 1986 is presented (Fig. 7). Comparing Figs 6 and 7 and considering the period from 10 June (when the summer monsoon had established in South-East Asia) through mid-September 1986, two significant features can be noted:

(a) the disappearance of a ridge together with the development of a near-equatorial trough over the equatorial South China Sea and its northward movement coincided with the strengthening of 850 hPa westerly winds and relatively lower surface pressure over Peninsular Malaysia. During this period, rainfall in Peninsular Malaysia, and Sabah and Sarawak (located in northern Borneo) was relatively lower. This period can be considered as the active phase of the summer monsoon (during 10 June to 5 July and 25 July to 10 August);

(b) the presence of a ridge and the disappearance of a trough over the equatorial South China Sea coincided with the weakening of 850 hPa westerly winds and relatively higher surface pressure over Peninsular Malaysia. During this period rainfall in Peninsular Malaysia, Sabah and Sarawak was relatively higher. This period is considered as the monsoon break (10 to 24 July and 21 August to early September).

Although the May to September 1986 rainfall series of Indo-China and Philippines are not shown in Fig. 6, it is well known from monsoon climatology that these regions experience maximum rainfall during the active phase of the summer monsoon and vice versa. However, the relationship between the 850 hPa westerly winds, surface pressure and rainfall of Malaysia during the 1986 summer monsoon described earlier seems to show that the reverse is true. This may be due to the fact that Peninsular Malaysia is situated on the leeward side of the Sumatra mountain range during the days of southwesterlies. Hence it is under the influence of subsidence after the southwesterlies cross the Sumatra range. Furthermore, the maximum southwesterly winds are normally located north of Peninsular Malaysia, Sabah and Sarawak during the active phase of the summer monsoon. Hence these states are located in the region of anticyclonic shear with respect of the maximum westerlies. On the other hand, Indo-China is situated in the region of cyclonic shear with respect to the maximum westerlies. During the break of summer monsoon, low-level westerly winds over Malaysia weaken and at times may even back to southerlies or southeasterlies. The weakening of the low-level westerlies may result in weaker vertical sheer. A weakening of vertical shear generally favours convective activity. During severe break periods when low-level winds back from westerlies to southerlies or southeasterlies over Peninsular Malaysia, low-level covergence which favours convective activity tends to prevail over Peninsular Malaysia. One example is given in Fig. 8 which is the 850 hPa streamline analysis for 9 June 1986. Convergence between the sea-breeze and prevailing easterly winds along the west coast of Peninsular Malaysia may be the other additional factor in the enhancement of convective activity (Cheang 1972) over Peninsular Malaysia during the monsoon break.

**Fig. 8 850 hPa streamline analysis over Asia and west Pacific 9 June 1986.**




## Tropical storms and typhoons in the South China Sea

The occurrence of tropical depressions, tropical storms and typhoons by month is given in Table 1 and compared with the 1968-1986 average (in parenthesis) computed from storm data obtained from the Hong Kong Royal Observatory. Except for the month of May 1986, the occurrence of tropical storms/typhoons was slightly below the average in June, July, August and September. To explain qualitatively the below average occurrence of tropical storms/typhoons over the South China Sea, we refer to the sea surface temperature anomaly and the 950 hPa and 200 hPa wind anomaly charts of Kingston et al. (1987). Since major parts of the South China Sea have about normal SST except for a small area off the coast of Vietnam where a negative anomaly is noted, this SST anomaly probably did not contribute to the below average occurrence of tropical storms/typhoons.

The above average for the month of May 1986 may be attributed to the presence at the low level of a stronger westerly anomaly over the central part of the South China Sea and easterly anomaly over southern China. This might have led to a more active monsoon trough, conducive to cyclogenesis. Overlying the more active monsoon trough is the upper anticyclone anomaly which is another factor favourable for cyclogenesis. From July to September, the most dominant features in the anomaly charts of Kingston et al. are the easterly and southerly anomalies at the low level, and a large upper low anomaly over the Gulf of Thailand during July and August 1986. The low-level anomaly is an indication of a weakening monsoon trough whereas the upper-level anomaly is also not conducive to cyclogenesis since upper low is usually connected with subsidence.

**Table 1. Occurrence of depressions, tropical storms and typhoons over the South China Sea during May to September 1986.**

| *Month* | *Depression* | *Tropical storm/typhoon* |
|---|---|---|
| May | 1(0.05) | 2(0.3) |
| June | 1(0.1) | 0(0.8) |
| July | 0(0.05) | 1(1.5) |
| August | 1(0.2) | 1(1.3) |
| September | 0(0.1) | 0(1.35) |

## Summary

On the whole the summer monsoon of South-East Asia from May through September 1986 was weaker than normal in terms of rainfall due to the weaker monsoon trough activity shown in the circulation anomaly charts of Kingston et al. (1987). The Philippines is the only country which experienced wetter weather during August and September which may be attributed to the presence of low-level cyclonic anomaly.

The onset of the monsoon in Indo-China and Peninsular Malaysia was found to be 9 May. It took about one month for the southwesterlies to become established in the whole of South-East Asia. The delay is mainly due to the intermittent intrusion of easterlies from the west Pacific. A cyclonic vortex was found to move across Peninsular Malaysia from the South China Sea and intensify over the Bay of Bengal just before the onset of the monsoon over Indo-China and Peninsular Malaysia.

A 20 to 40 day mode of oscillation was a dominant feature in the filtered series of surface pressure of South-East Asia and the west Pacific, 850 hPa and 200 hPa east and west-winds and rainfall of Malaysia. This oscillation was related to the active and break cycle of the monsoon. Rainfall in Malaysia was found to be low (high) during the active (break) phase of the monsoon.

Tropical storm/typhoon activity was below normal. This may be attributed to the weaker than normal monsoon trough activity in the South China Sea region.

## Acknowledgment

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