ROYAL OBSERVATORY, HONG KONG

Technical Note (Local) No. 54

AN UNUSUAL SHOWERY EVENT IN HONG KONG WITH RETREATING COOL EASTERLIES IN JUNE 1989

by

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1. INTRODUCTION

Relatively cool easterlies of continental origin arrived at Hong Kong on the morning of 20 June 1989, bringing some showers and thunderstorms. Contrary to usual expectation, however, heavier rain occurred locally when the easterlies retreated on 22 June. Over 60 millimetres of rain were recorded at the Royal Observatory that day. The main objective of this report is to study the synoptic features associated with this showery occasion.

2. RAINFALL, RADAR AND SATELLITE OBSERVATIONS

(a) Rainfall

Table 1 presents rainfall figures at the Royal Observatory during the period 20 - 22 June 1989.

On 20 June, 3.5 mm of rain were recorded at the Royal Observatory. The most, 37.8 mm, fell over the western part of Hong Kong Island.

On 22 June, 64.5 mm of rain were recorded at the Royal Observatory between midnight and noon, while over the same period a station in the northern part of Hong Kong Island reported rainfall close to 100 mm and another station in Lantau Island reported rainfall in excess of 120 mm.

The rainfall distributions over Hong Kong are given in Figs. 1a and 1b respectively for 20 and 22 June.

(b) Radar Observations

Two sequences of radar echoes, one for 20 June and the other for 22 June, are shown respectively in Fig. 2 and Fig. 3. From Fig. 2, echoes, signifying the front edge of the easterlies, first appeared to the east of Hong Kong at 19 1900HKT*. They then moved west and developed as the easterlies strengthened on the 20th. As most of the development occurred to west of Hong Kong, not much rainfall was recorded locally. On the 22nd, echoes first appeared to the west of Hong Kong and then moved eastward as the easterlies retreated.

(c) Satellite Observations

Satellite pictures taken at 00 UTC for the four consecutive days 19-22 June 1989 are shown in Figs. 4a(i), b(i), c(i) and d(i). Although the areal extent of convective clouds was less on 22 June compared with that on 20 June, the rain-bearing clouds stayed over Hong Kong for a larger duration of time, giving rise to more rain locally.

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*'19 1900HKT' denotes 1900HKT on 19 June; HKT is 8 hours ahead of UTC.

3. SYNOPTIC SITUATION

The evolution of synoptic systems during the period 19 - 22 June 1989 is shown schematically in Fig. 4a(ii), b(ii), c(ii) and d(ii).

On 19 June, a north-south oriented quasi-stationary trough at 500 hPa level extended far south from the sea of Japan to east of Taiwan, while an anticyclone resided over south China. On the surface is a trough (Fig. 4a(ii)) demarcating the convergence zone between the cooler air, around 22°C, from the north and the warm moist southwesterlies, around 28°C that prevailed over south China. The subsiding air behind the 500 hPa trough resulted in the building of an anticyclone over east China and thus an easterly surge on 19 1500 UTC. The surface trough was pushed to west of the Pearl estuary and brought about showers and thunderstorms as it passed over Hong Kong. The convergence zone, in the form of a band of high clouds indicating deep convection, can be seen on the satellite picture (Fig. 4b(i)). Accompanying the arrival of the surge, winds at low level backed from southwesterlies to southeasterlies at 19 1200 UTC (Fig. 5a). The surge also resulted in a drop of around 3 degrees in just 3 hours, from 28°C to 25°C, at Hong Kong immediately after its arrival at 19 1500 UTC.

A narrow ridge of high pressure became established along the coast of southeast China and easterlies prevailed on 20 and 21 June. During this period, the trough stayed to the west of the Pearl estuary and south of Hong Kong. The cool easterlies were gradually modified and the convective activity associated with the trough subsided (Fig. 4c(i)). The surface trough finally dissipated at 21 1500 UTC.

Meanwhile, a 500-hPa wave developed over northeast China within the main quasi-stationary trough. This is reflected on the surface by another trough forming over Guangxi and northern Guangdong at 21 0900 UTC. As this surface trough deepened, active southwesterlies were drawn towards the trough and showers and thunderstorms occurred along the surface trough.

The 500-hPa wave started to swing south later on the 21st, displacing the anticyclone over Hong Kong westwards to Beibu Wan. In response, the trough at 700 hPa, 850 hPa and surface also started to move south. The southwesterlies over south China became more active as indicated by the intense convective activity in the vicinity of the trough. As the southwesterlies picked up in strength, the easterlies retreated. At 21 1200 UTC surface winds at Macau began to veer to southerlies (Fig. 5b). The confluence zone between the easterlies and the south/southwesterlies lied just to the west of the Pearl estuary.

Locally, the moist layer thickened and extended from the surface up to 600 hPa level (Fig. 6a and b) at 22 0000 UTC. The K index also increased from 30 to 39. At the same time, a narrow band of showers developed to west of the Pearl estuary (Fig. 4d(i)). As the winds at 700 and 850 hPa level veered to southwesterlies between 22 0000 UTC and 22 0600 UTC, these showers moved across and brought appreciable rainfall to Hong Kong that morning. By 22 0600 UTC, the southwesterlies at 700 and 850 hPa level became established (Fig. 5b). The evolution of the streamline pattern at 850 hPa level from 22 0000 UTC to 22 0600 UTC are shown in Fig. 7a and b. With the confluence between the southwesterlies and easterlies moving to our east and disappearing, rain stopped in Hong Kong in the afternoon. The synoptic situation in association with the observed rain event is illustrated in Fig. 8 schematically.

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* K index = $(T_{850} - T_{500}) + T_{d850} - (T_{700} - T_{d700})$
where T_{xxx} denotes the temperature at xxx hPa
and T_{dxxx} denotes the dew-point temperature at xxx hPa

4. CONCLUSIONS

Against the usual expectation of reasonable weather when continental easterlies on the surface are on the retreat, heavy showers occurred in Hong Kong on 22 June 1989.

The adverse weather on 22 June can be attributed to the following:-

(a) the gradual weakening of cool easterlies on the surface and the return of the convergence zone between the easterlies and the warm and moist southwesterlies; and

(b) a wave disturbance at 500 hPa, displacing the 500-hPa ridge over our area, causing troughs at lower levels to deepen and thereby enhancing the southwesterlies at these levels.

DATE	TOTAL DAILY RAINFALL	REMARKS
JUNE 20	3.5 mm	occurred between midnight and 0600HKT upon the arrival of easterlies. Thunderstorms occurred at Cheung Chau from 0300HKT to 0500HKT.
JUNE 21	1.0 mm	0.3 mm fell between 0200HKT and 0800HKT. 0.7 mm fell between 2000HKT and midnight.
JUNE 22	64.5 mm	occurred between midnight and noon. Of these, 25.8 mm occurred between 0900HKT and 1000HKT alone.

TABLE 1 RAINFALL RECORDED AT THE ROYAL OBSERVATORY HONG KONG DURING 20 - 22 JUNE 1989

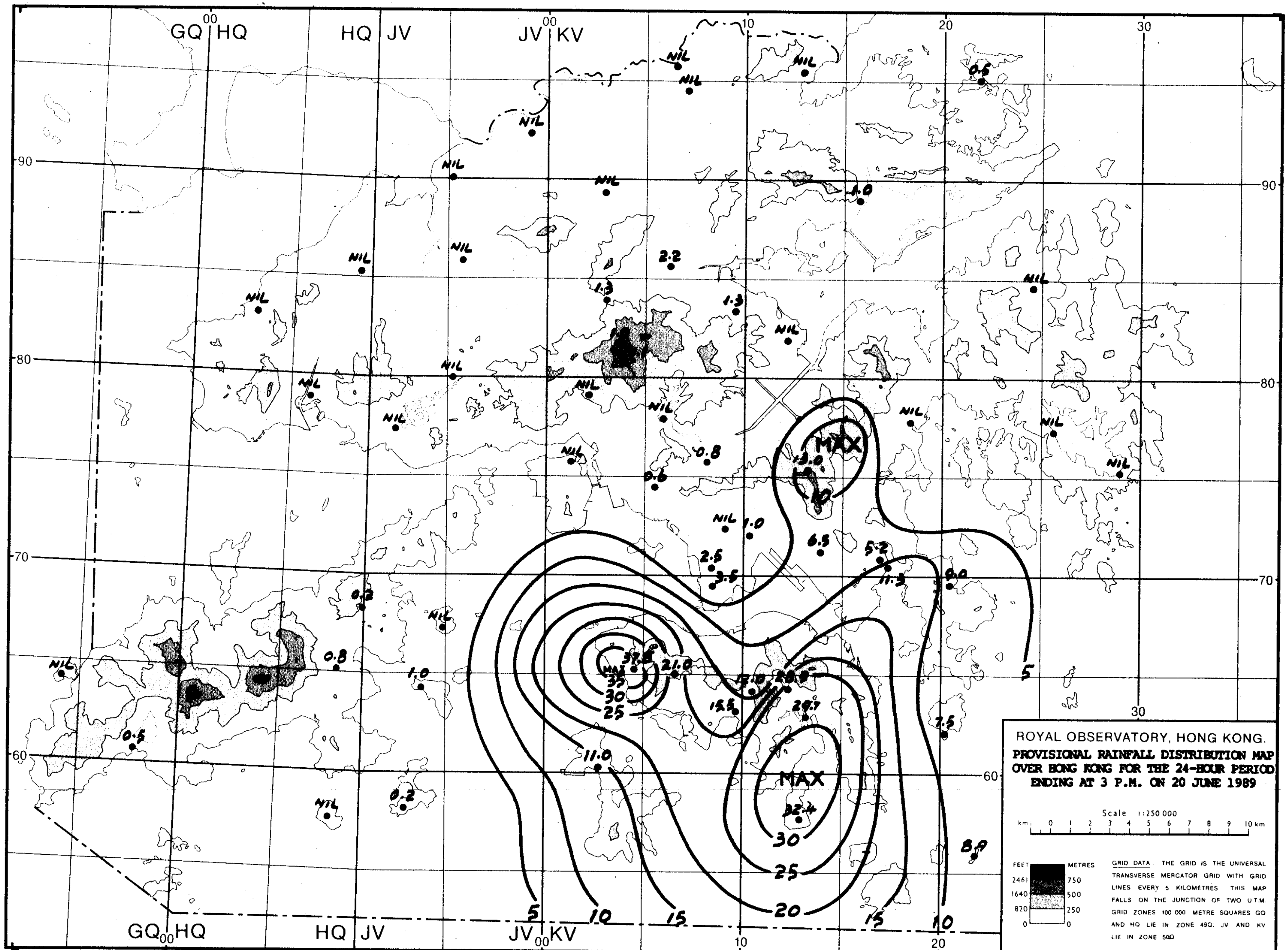

Fig. 1a Rainfall distribution over Hong Kong for the 24-hour period ending at 3 p.m. on 20 June 1989

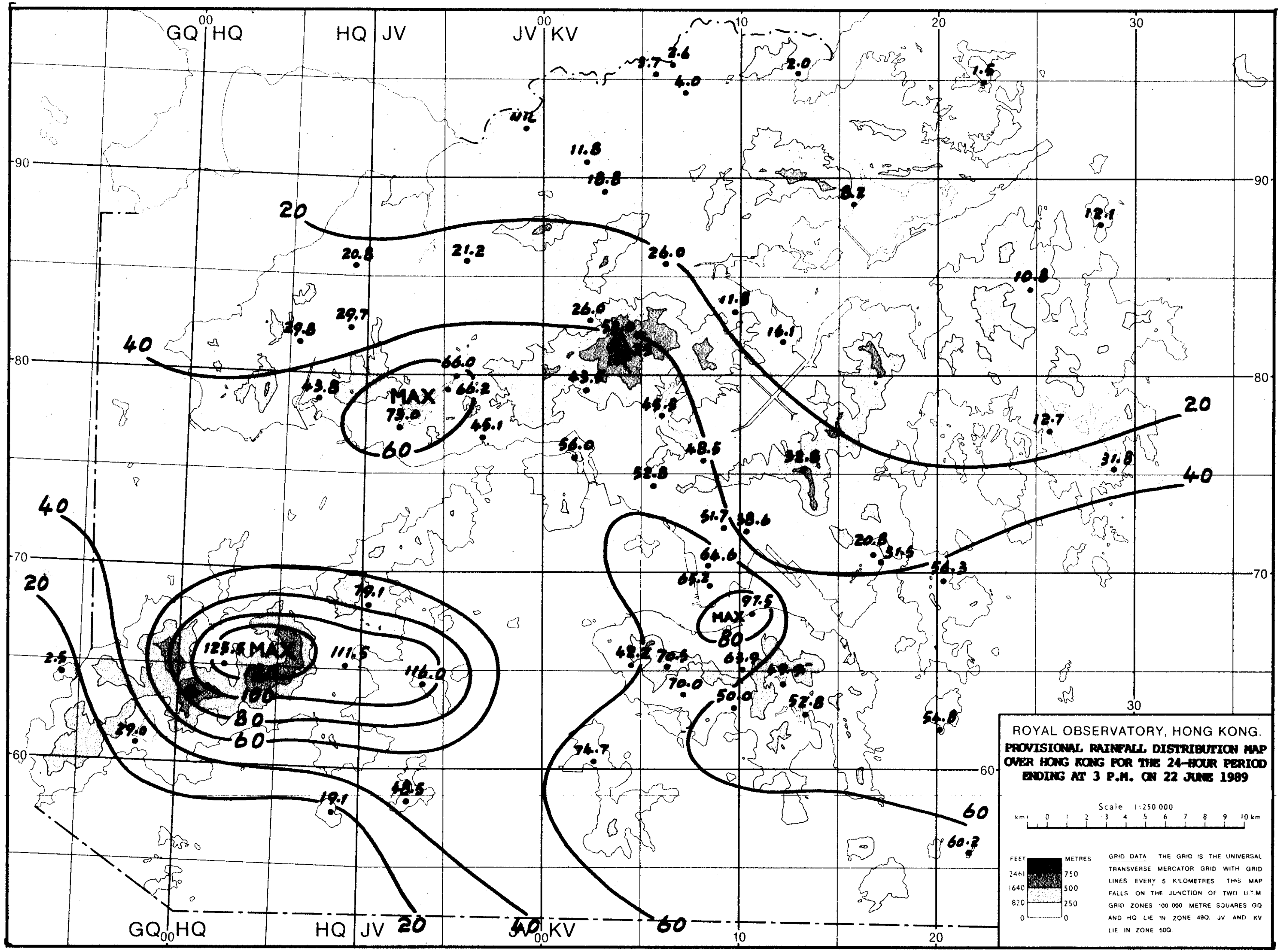

Fig. 1b Rainfall distribution over Hong Kong for the 24-hour period ending at 3 p.m. on 22 June 1989.

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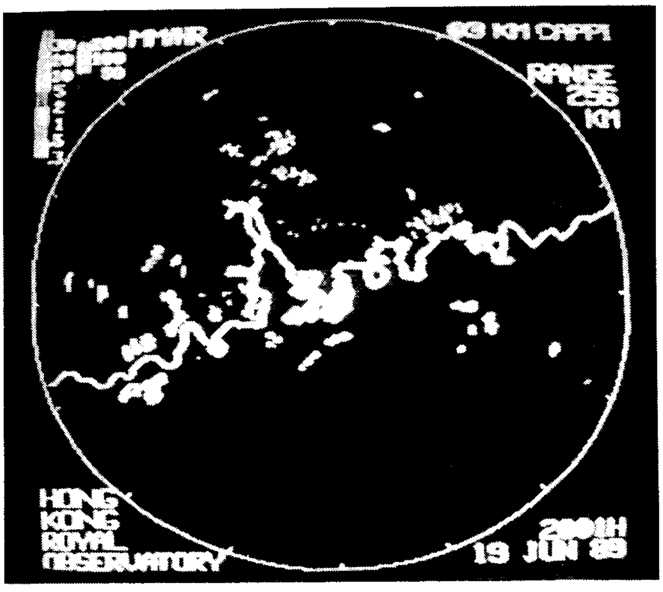
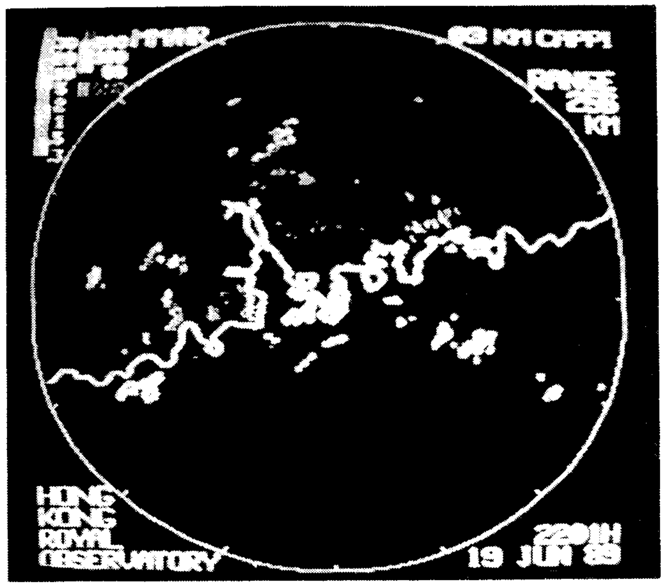
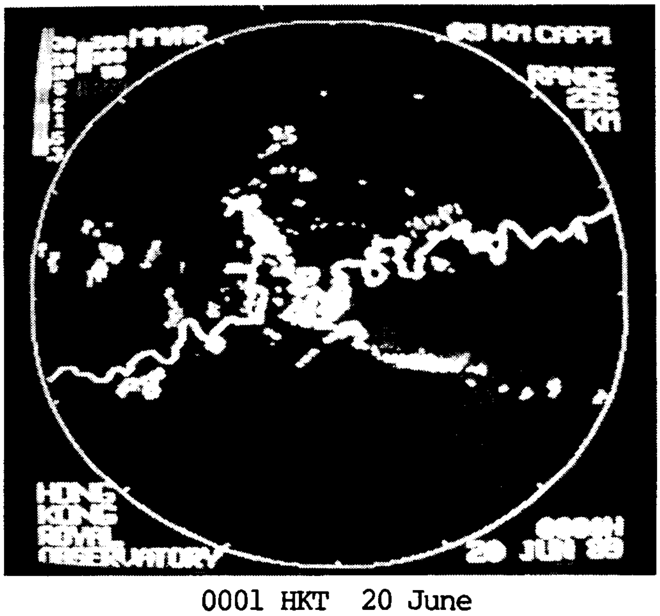


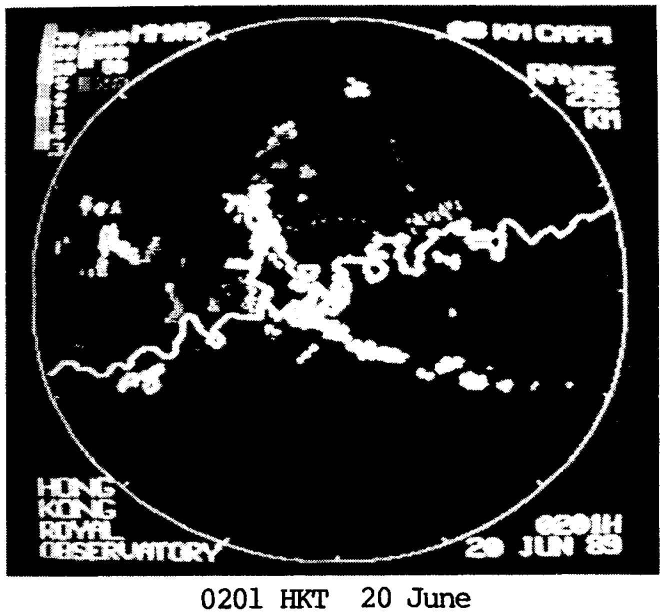
2001 HKT 19 June



2201 HKT 19 June



0001 HKT 20 June



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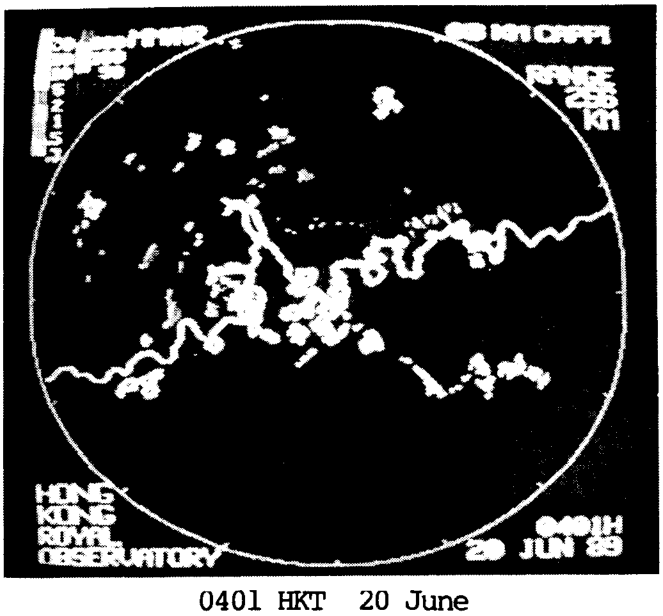

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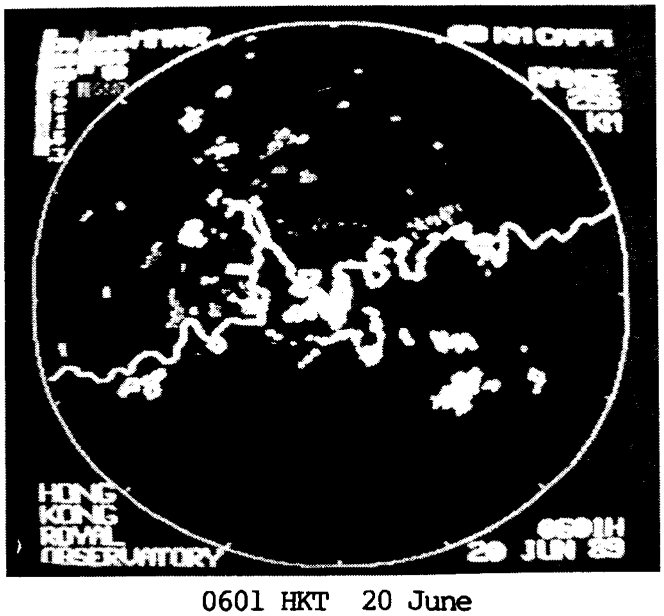
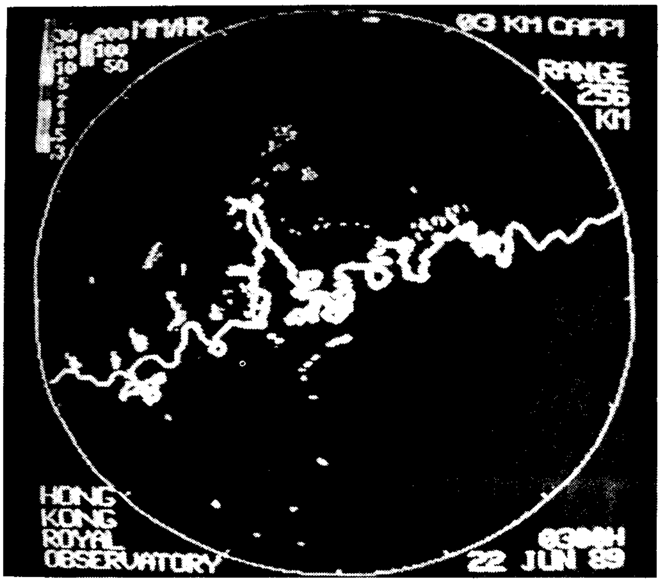
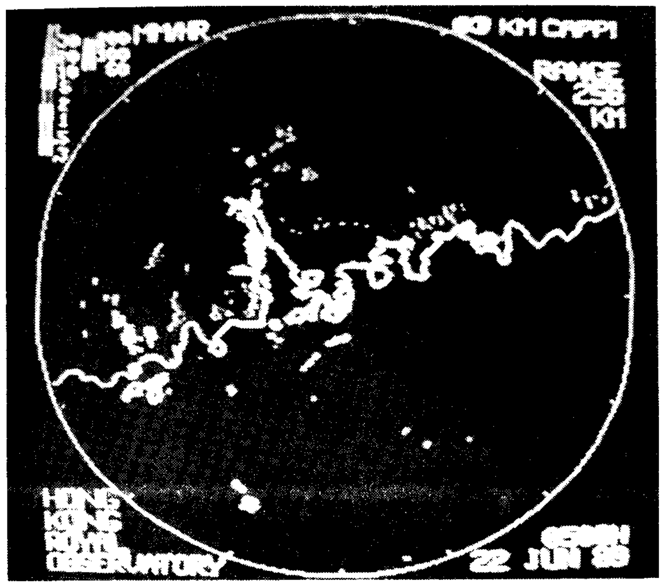


0601 HKT 20 June

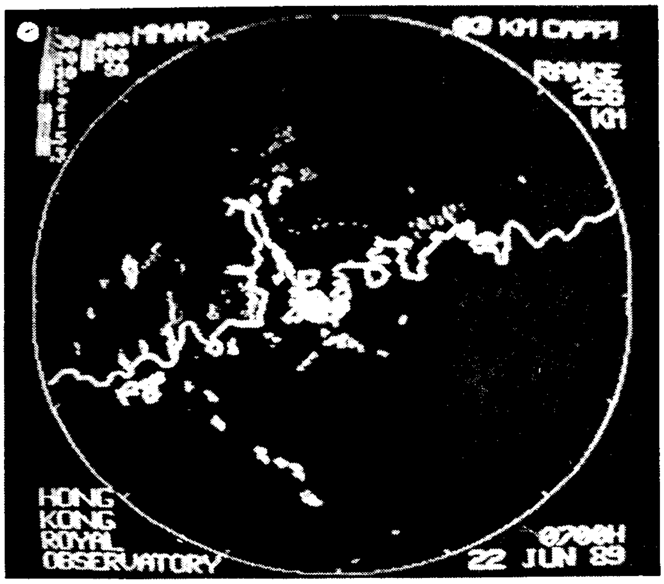
Fig. 2 Radar sequence of the rain event on 20 June 1989.



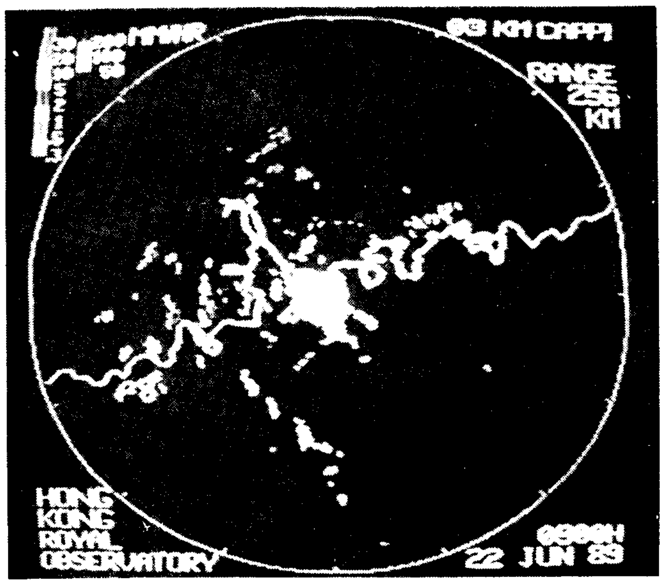
0300 HKT 22 June



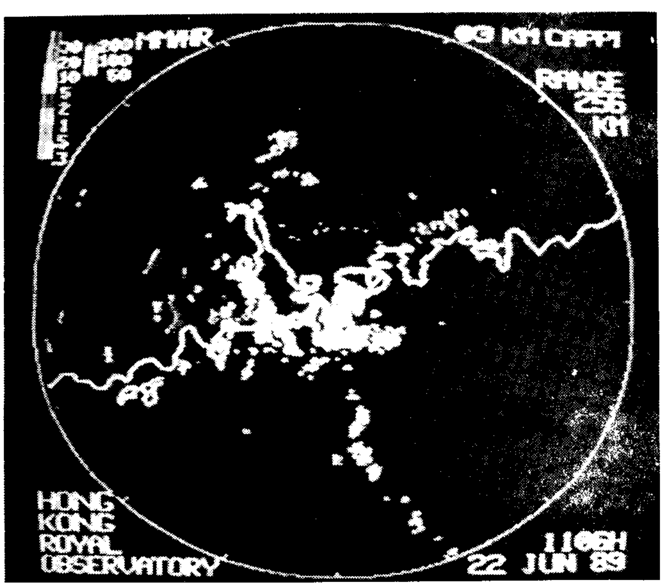
0500 HKT 22 June



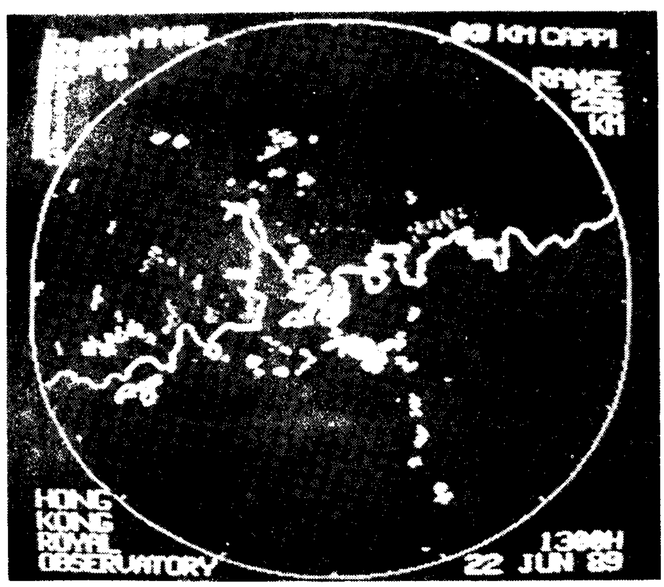
0700 HKT 22 June



0900 HKT 22 June

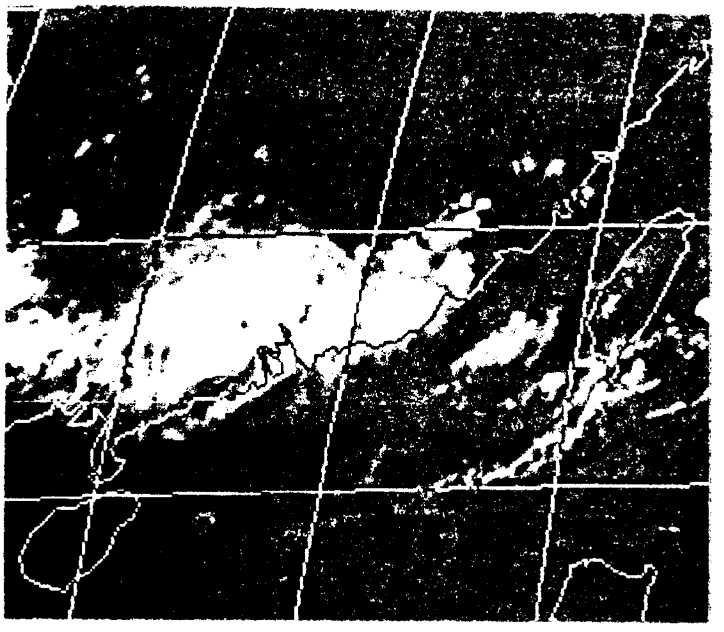


1106 HKT 22 June

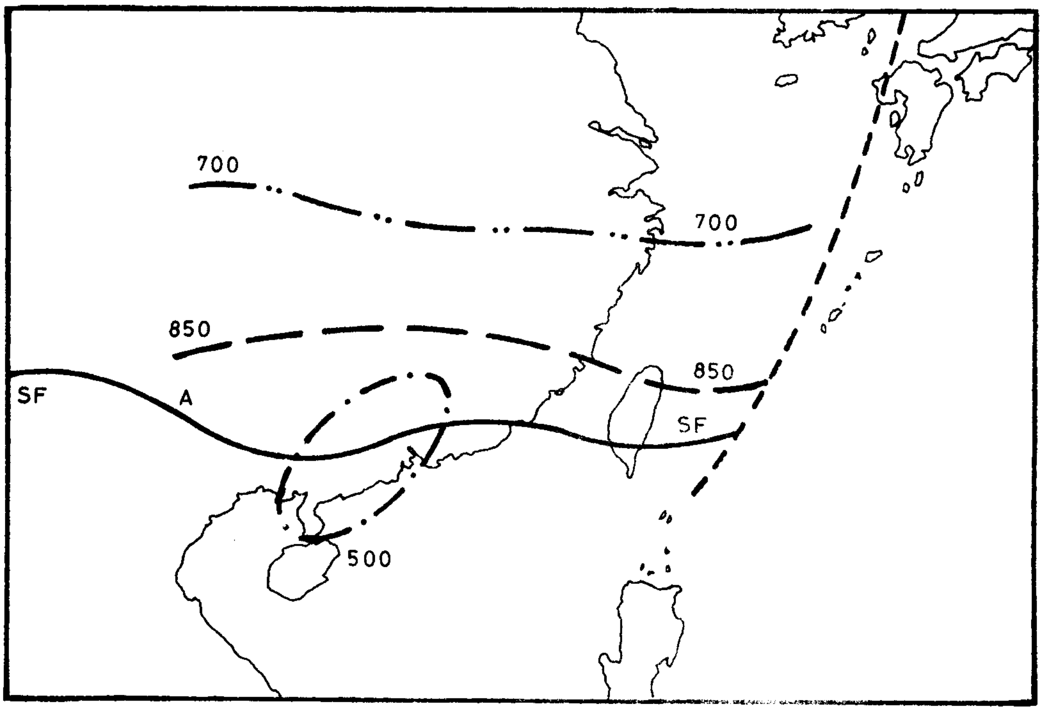


1300 HKT 22 June

Fig. 3 Radar sequence of the rain event on 22 June 1989.

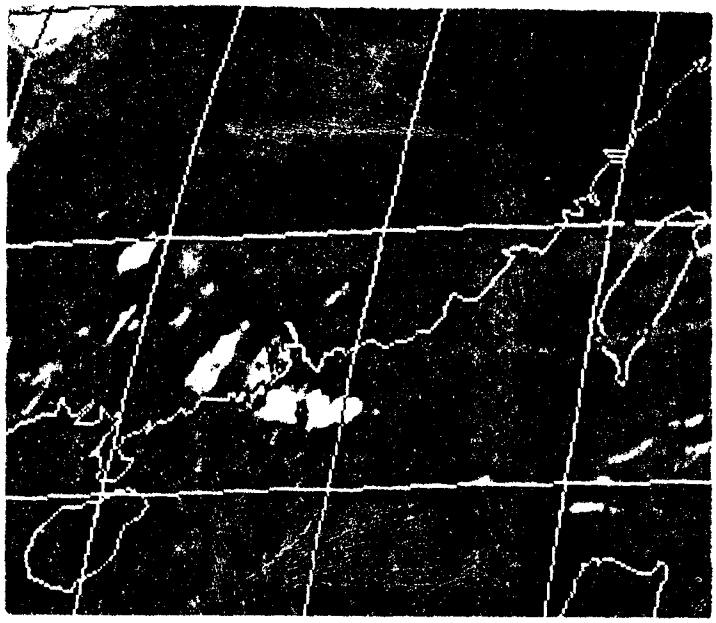


(i)

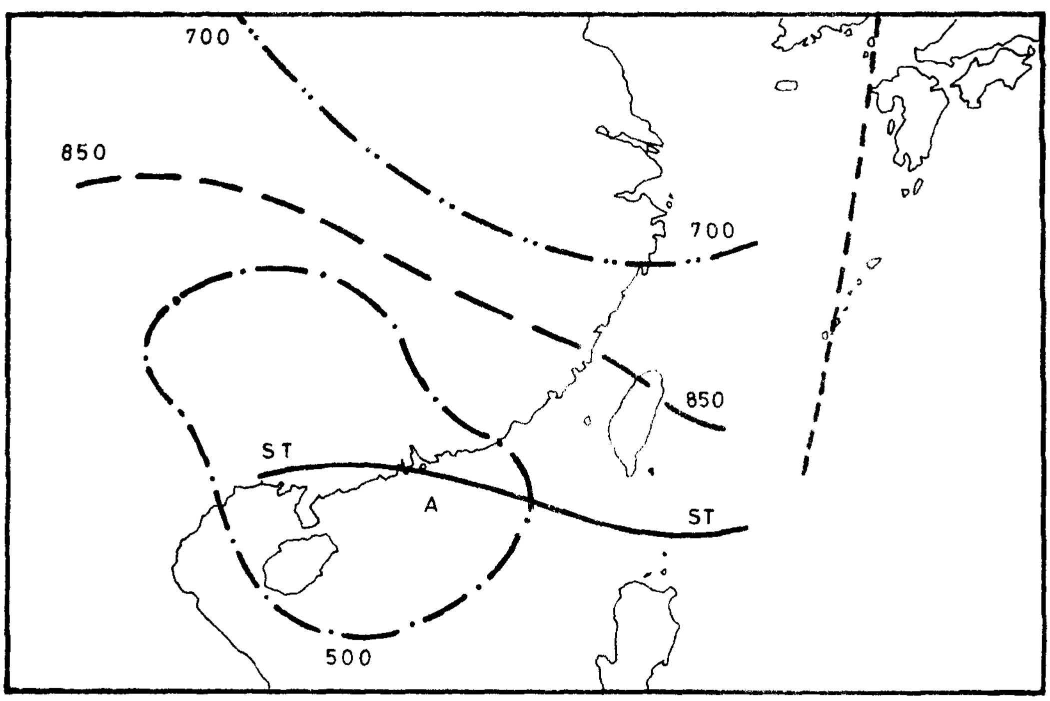


(ii)

Fig. 4a (i) Satellite picture of south China at 19 0000 UTC
(ii) Schematic diagram of the synoptic systems at 19 0000 UTC. Axis of the first surface trough (A) is represented by ——— . The 850 hPa trough axis is represented by — — , the 700 hPa trough axis by —··— , and the 500 hPa trough axis by – – – – . —·— depicts the area with geopotential height above 5880 m at 500 hPa level.

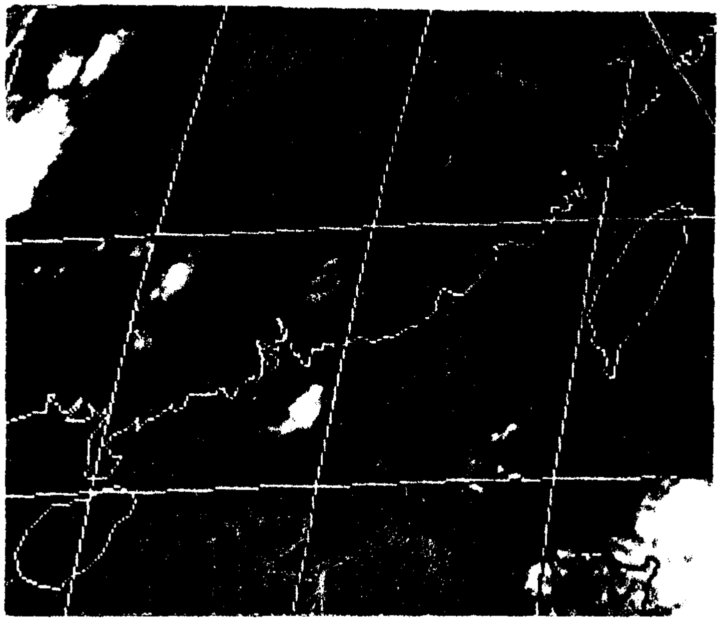


(i)

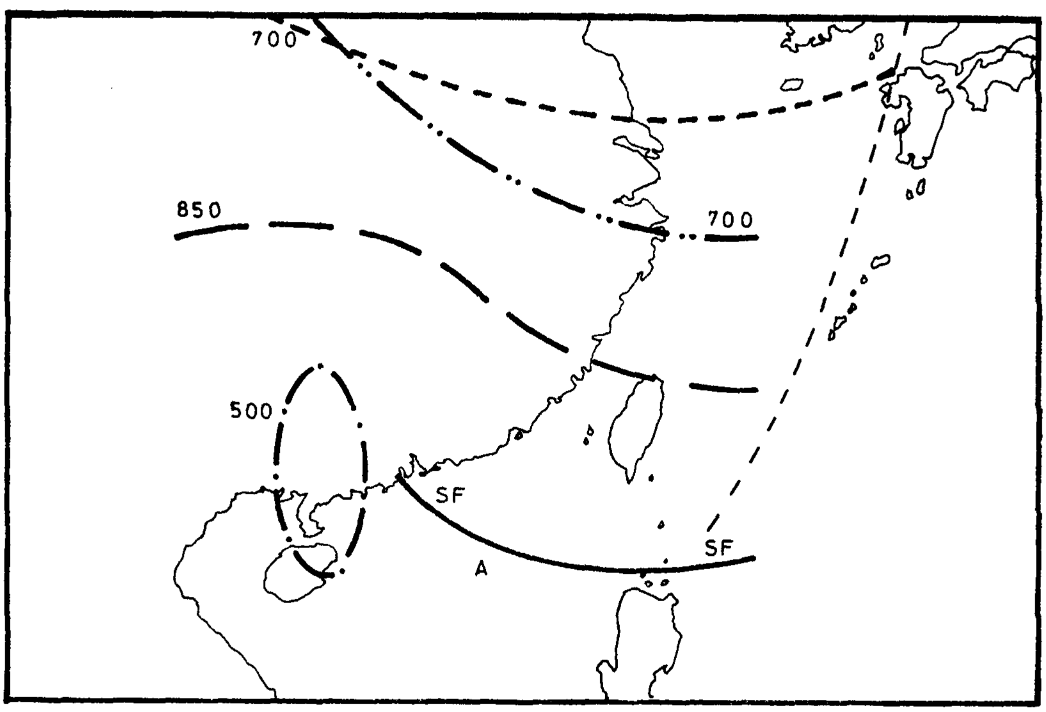


(ii)

Fig. 4b (i) Satellite picture of south China at 20 0000 UTC
(ii) Schematic diagram of the synoptic systems at 20 0000 UTC. Axis of the surface trough (A) is represented by ——— . The 850 hPa trough axis is represented by — — , the 700 hPa trough axis by —··— , and the 500 hPa trough axis by - - - - . —·— depicts the area with geopotential height above 5880 m at 500 hPa level.

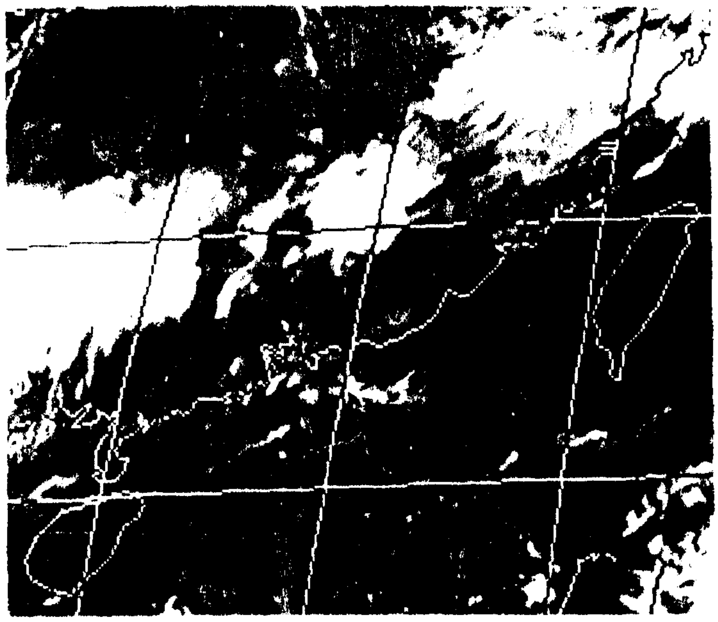


(i)

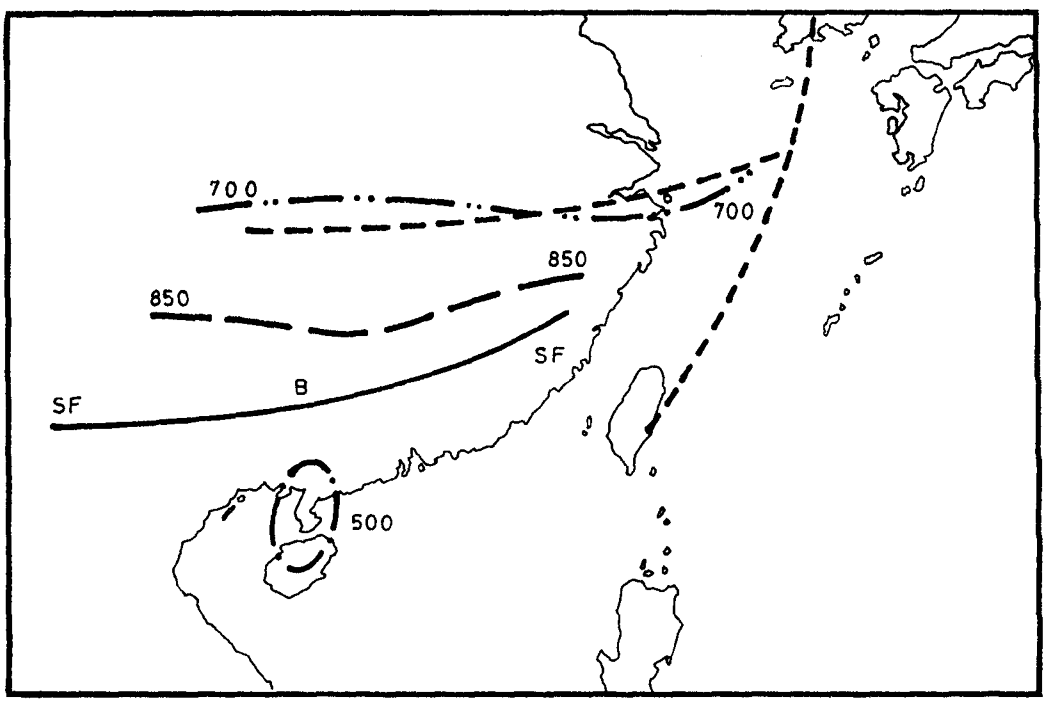


(ii)

Fig. 4c (i) Satellite picture of south China at 21 0000 UTC
(ii) Schematic diagram of the synoptic systems at 21 0000 UTC. Surface trough (A) represented by ——— is weakening. The 850 hPa trough axis is represented by — — , the 700 hPa trough axis by —··— , and the 500 hPa trough axis by - - - - . —·— depicts the area with geopotential height above 5880 m at 500 hPa level.



(i)



(ii)

Fig. 4d (i) Satellite picture of south China at 22 0000 UTC
(ii) Schematic diagram of the synoptic systems at 22 0000 UTC. Axis of the second surface trough (B) is represented by ———. The 850 hPa trough axis is represented by — —, the 700 hPa trough axis by —··—, and the 500 hPa trough axis by - - - -. —·— depicts the area with geopotential height above 5880 m at 500 hPa level.

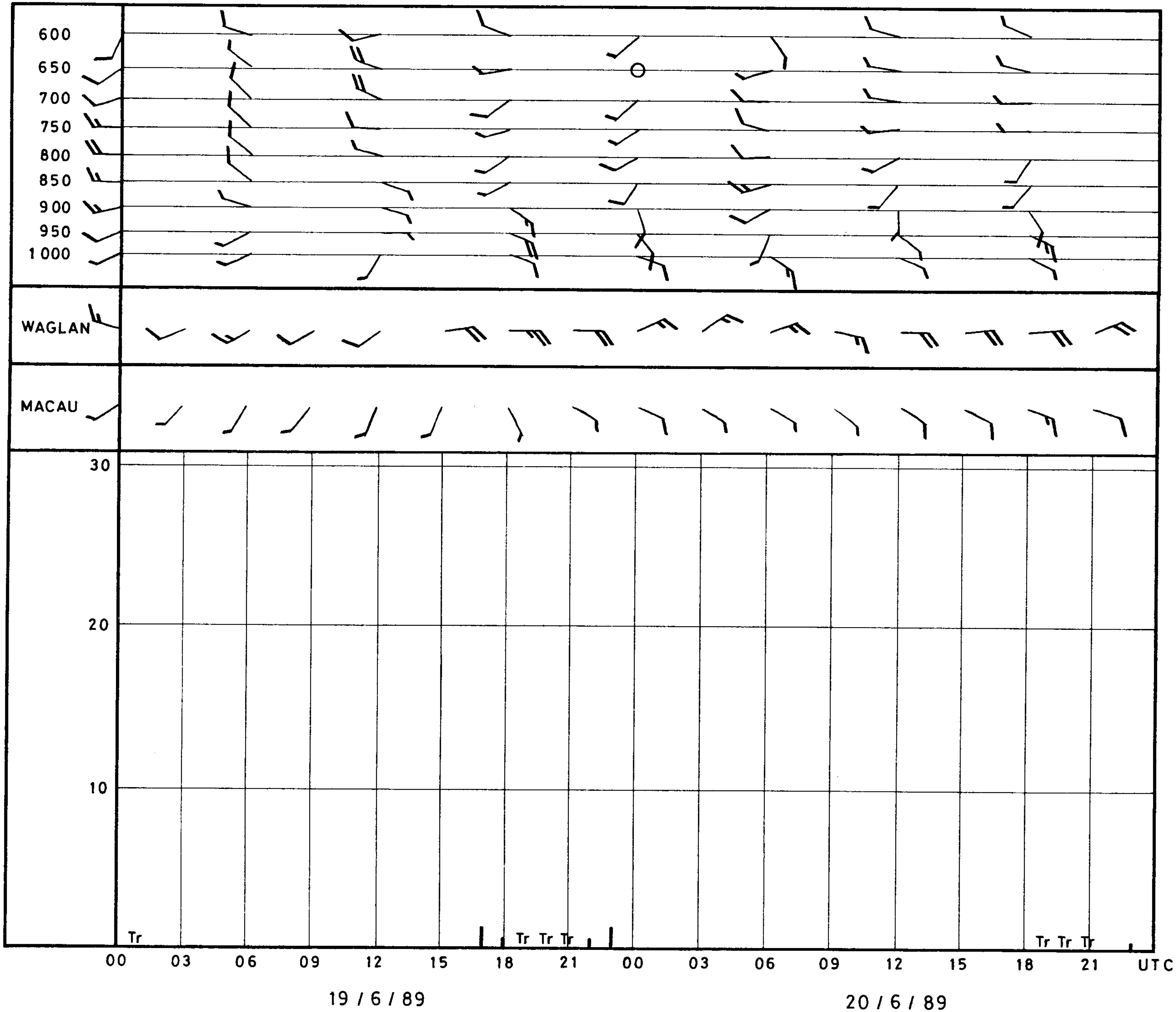


Fig. 5a Time cross-section of upper air winds and rainfall recorded at the Royal Observatory

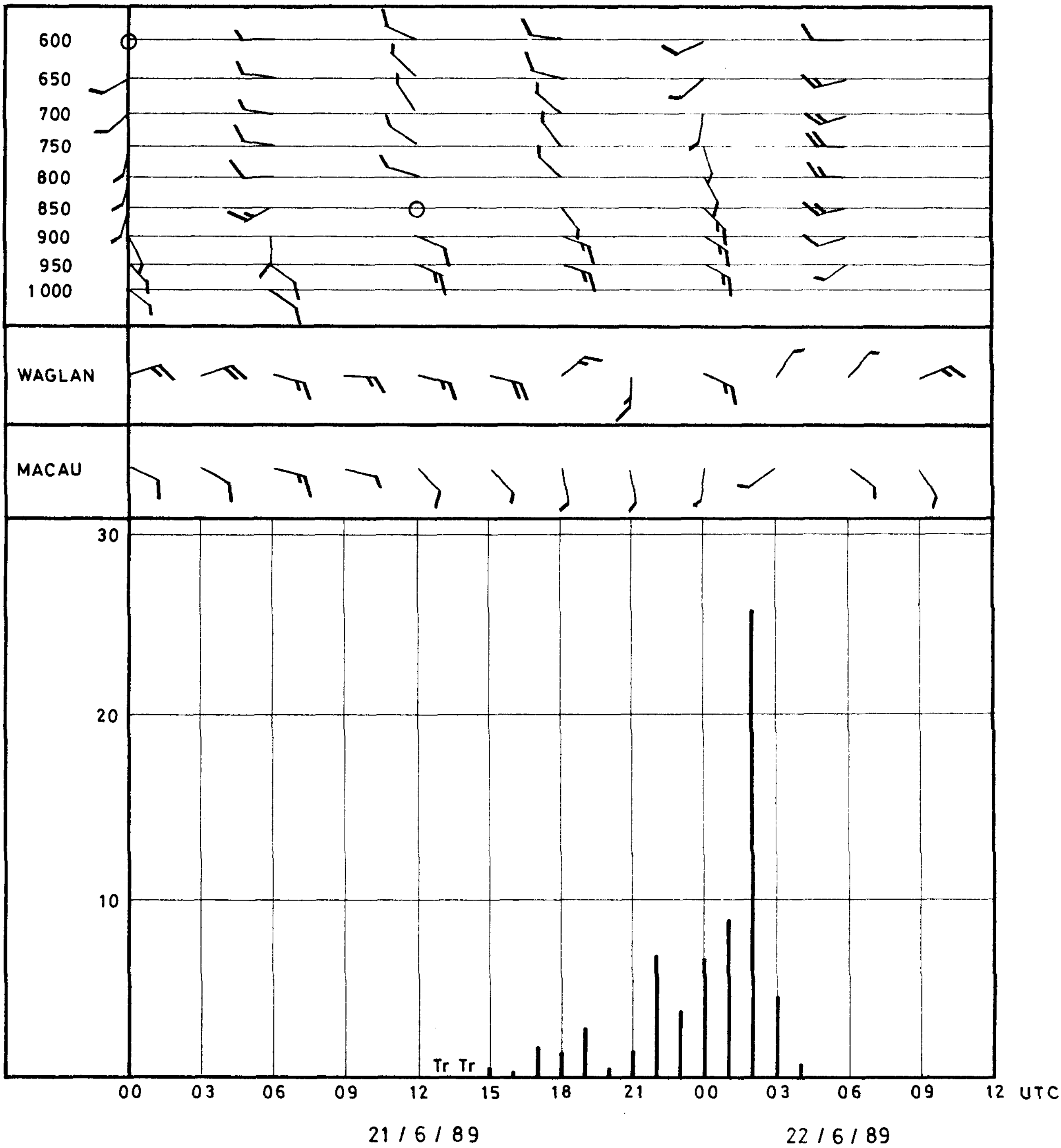


Fig. 5b Time cross-section of upper air winds and rainfall recorded at the Royal Observatory.

Fig. 6a Tephigram at King's Park Meteorological Office at 21 1200 UTC.

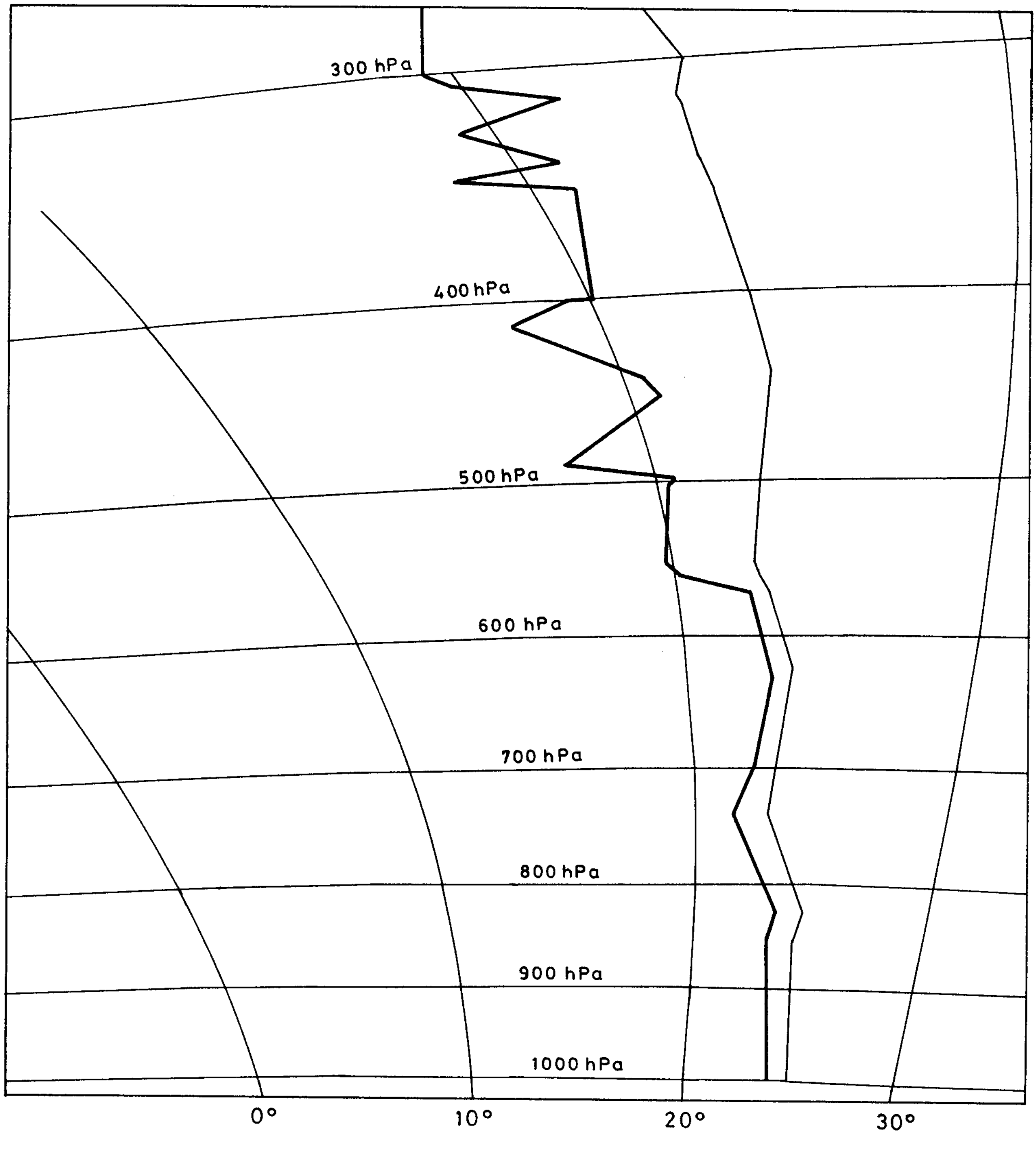


Fig. 6b Tephigram at King's Park Meteorological Office at 22 1200 UTC.

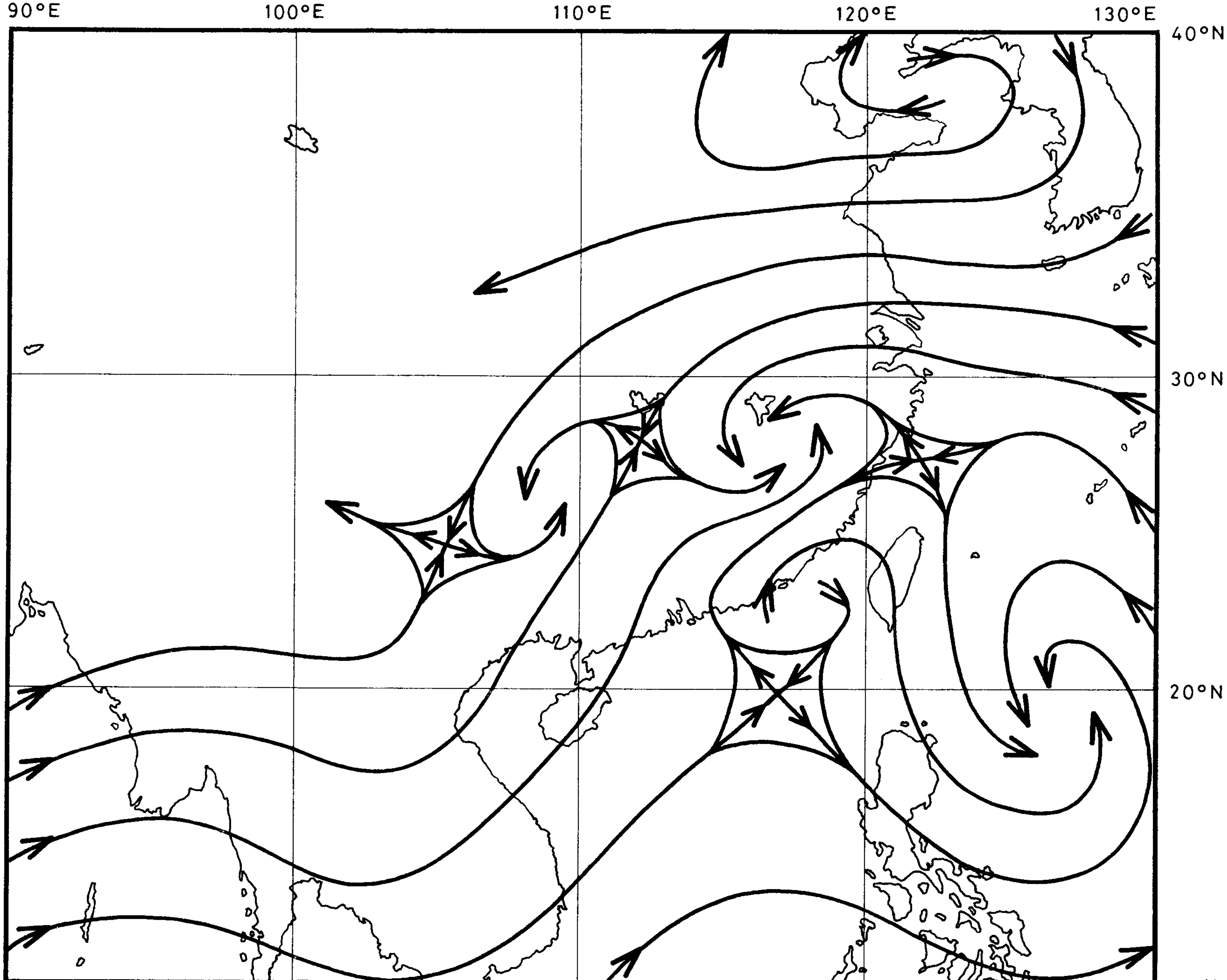


Fig. 7a Chart for 850 hPa surface valid for 0000 UTC on 22 June 1989.

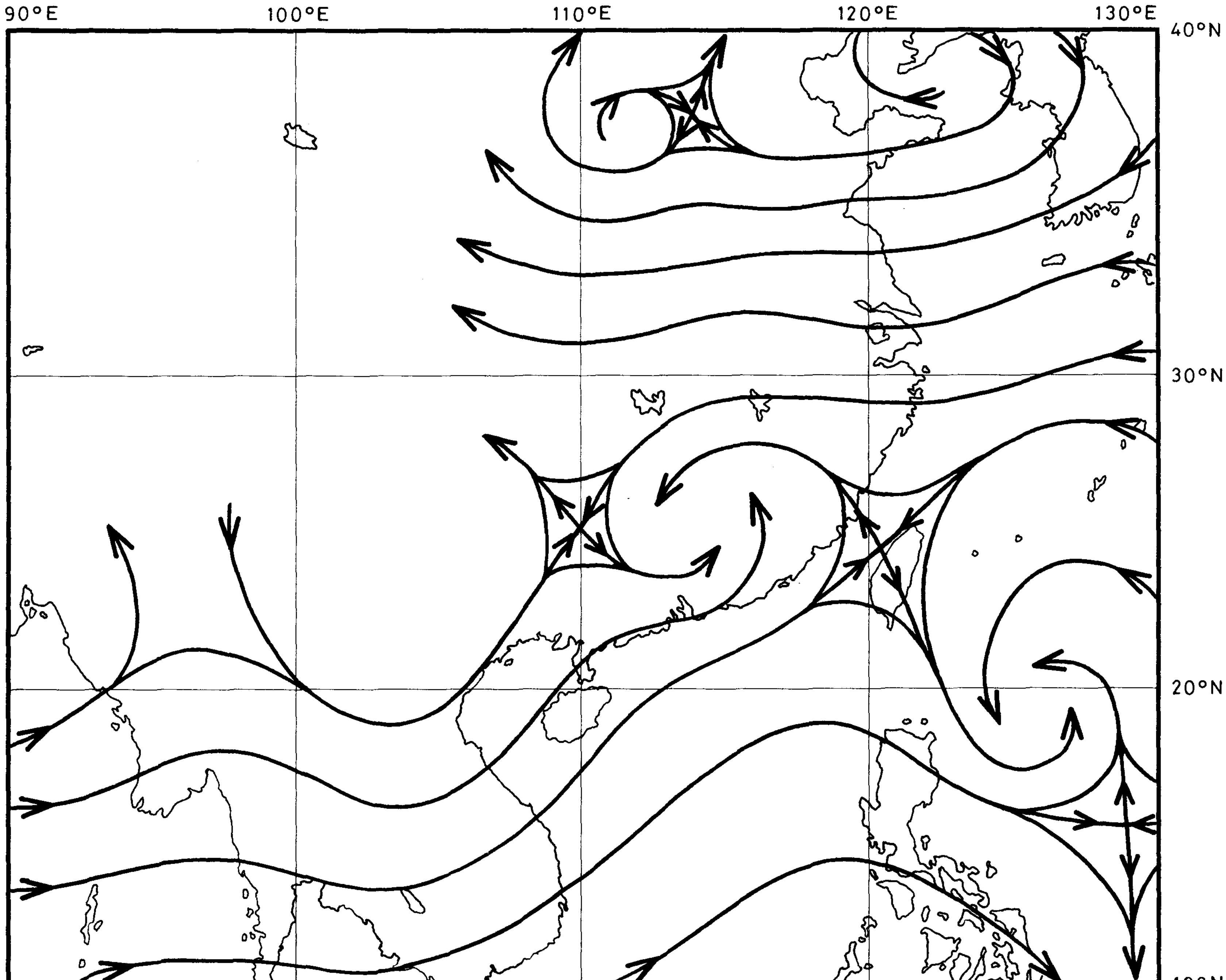


Fig. 7b Chart for 850 hPa surface valid for 0600 UTC on 22 June 1989.

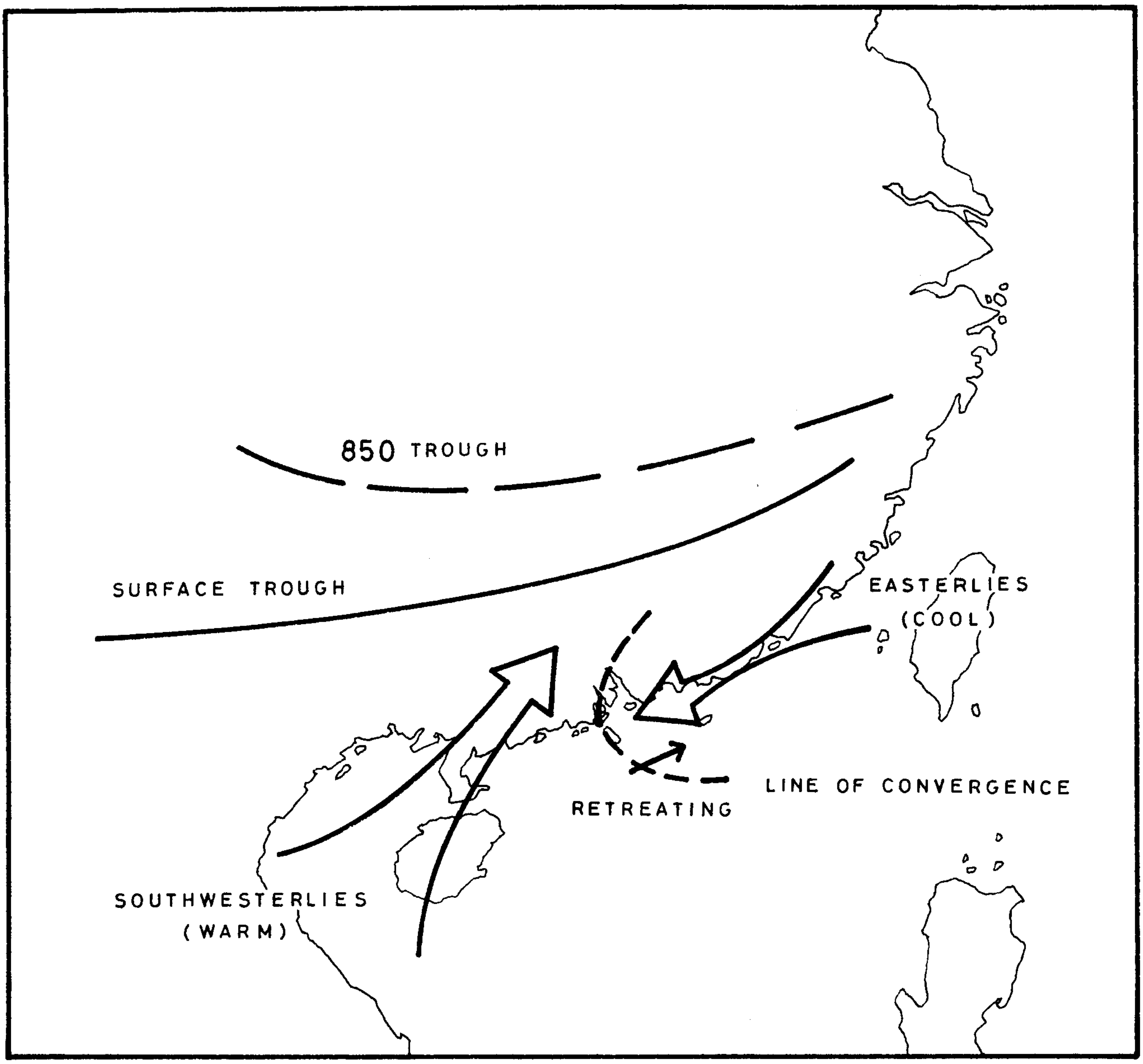


Fig. 8 Schematic diagram for the synoptic situation in association with the rain event on 22 June 1989. The surface and 850 hPa trough axis are depicted by ———— and —— —— lines respectively; the different airstreams at low levels by arrows and the line of convergence between easterlies and southwesterlies by – – – – –.