

The Heavy Rain Associated with Severe Tropical Storm Helen (1995)

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ABSTRACT

The heavy rain brought on by Severe Tropical Storm Helen and its remnant on 12 and 13 August 1995 caused serious flooding and landslides in Hong Kong. At the Royal Observatory Headquarters, the rainfall registered over these two days totalled 356.5 millimetres, ranking the sixth highest on record for rainfall of any two consecutive days in August. In terms of the areal rainfall distribution, there was a marked contrast between the northern and the southern part of the territory. More than 450 millimetres of rain were recorded on 12 and 13 August on the Hong Kong Island, but only some 150 millimetres were received in the northern New Territories over the same period.

On the synoptic scale, a low level jet at the 850 hPa level can be identified to the south of Helen and this is thought to have coupled with a significant divergence area further aloft at 200 hPa to produce a convectively unstable environment. While the atmospheric conditions were unstable over a wide region, the uneven distribution of rainfall in Hong Kong could be attributed to mesoscale development in the form of a narrow band moving in from the southwest of the Hong Kong waters to mainly batter the Hong Kong Island. This was very evident on weather radar albeit the lack of observations over the sea precluded detailed analysis.

1. Introduction

Severe Tropical Storm Helen affected Hong Kong on 9-12 August 1995. During Helen's passage, high winds brought down trees and scaffoldings in many places over the territory. But in many people's minds, the most unforgettable disasters were the flash floods and serious landslides that Helen and its remnant brought about from the evening of 12 August to the early morning of 13 August. The Royal Observatory had to issue the red rainstorm warning twice within a space of less than 12 hours during this period. In Helen's wake, three people were crushed to death in landslips in Chai Wan and Aberdeen on the Hong Kong Island, and many key roads were rendered impassable. The total rainfall recorded in these two days at the Royal Observatory Headquarters amounted to 356.5 millimetres, ranking the sixth highest for rainfall in any two consecutive days in August.

During the period of heavy downpours, rainfall distribution over the territory shows a rather uneven pattern (Fig. 1). While on average the northern New Territories received some 150 millimetres of rain, the Hong Kong Island took the brunt of the deluge with over 450 millimetres recorded. In this paper, the life history of Helen will be briefly recapped. Radar observations and synoptic charts will then be examined to elicit the possible contributing factors for these severe rainstorms. The interested reader is referred to publications such as Tao (1980) and Bao (1980) for further reading on tropical cyclone rainfall.

2. The life history of Helen

Figure 2 shows the provisional track of Severe Tropical Storm Helen (RO, 1995). Helen formed as a tropical depression over the western North Pacific about 1 190 km east of Manila on 7 August. Moving northwestwards, it intensified into a tropical storm on 9 August and entered the South China Sea the following day. Helen slowed down significantly and started to take a sharp turn to the right on the evening of 10 August towards the south China coast.

Tracking northwards, Helen intensified further into a severe tropical storm about 380 km south-southeast of Hong Kong. It came closest to Hong Kong about 50 km to the east on the morning of 12 August and made landfall at about 60 km to the northeast a few hours later. Over land, Helen weakened rapidly and dissipated that evening. However, Helen's remnant continued to affect the coast of Guangdong on the early morning of 13 August.

3. The rainfall in Hong Kong

To illustrate the temporal variation of rainfall in different locations in Hong Kong, rainfall time series from 1 a.m. of 12 August to midday of 13 August are shown for three selected stations, Yuen Long, the Royal Observatory Headquarters, and Happy Valley (Fig. 3). Their locations are also shown in Figure 1. From the time series, the rainfall associated with Helen could be regarded as coming in three episodes, the first during the close approach of Helen at about 5 a.m. of 12 August, the second from 11 a.m. to 5 p.m. of 12 August, and the third from 11 p.m. of 12 August to 3 a.m. of 13 August. In the first episode, the three stations received a fairly uniform amount of rain with the maximum hourly rainfall at 5 a.m. measured about 25 millimetres. In the second and the third episodes, rain was much more intense and was concentrated in the southern part of Hong Kong. Hourly rainfall in excess of 60 millimetres was registered in Happy Valley during the height of the heavy rain on the evening of 12 August and the early morning of 13 August.

The Royal Observatory's Doppler weather radar (Lee, et al. 1995) gives a better idea of the detailed process of these heavy rain episodes. In the first rainfall episode at about 5 a.m. of 12 August (Fig. 4a-b), Helen was located to the east of Hong Kong so that northerly winds prevailed over the territory at the low levels. The most active rainbands of Helen at the time were mainly to the south of the storm's circulation and hence Hong Kong was not too seriously affected. After Helen had made landfall, very intense echoes began to develop over the water to the southwest of Hong Kong in the evening and drifted northeastwards to hit the southern part of the territory. Individual radar echoes eventually joined together to form a narrow band which brought incessant rain especially to the Hong Kong Island near the midnight (Fig. 4c-d).

Surface winds in Hong Kong became southwesterly after Helen made landfall over China. On the evening of 12 August when Helen was about to dissipate, southwesterlies of around 25 to 30 knots were still recorded in the offshore areas and on the hill top (Fig. 5).

4. Synoptic situation

As discussed above, the most heavy rain in Hong Kong associated with Helen occurred after its landfall over China and when the local winds became southwesterly. ECMWF upper air analyses were examined for the possible mechanism of this heavy rain. Figure 6a-b show the 500 hPa height contour at 1200 UTC 10 August and 1200 UTC 11 August. An increase in the 500 hPa geopotential height was observed to the southeast of Helen. Possibly as a result of this, Helen turned sharply towards the north in the evening of 10 August. Tropical cyclone turning motion of this kind has been discussed in Wang and Fei (1987). Similarly at the 850 hPa level, anticyclonic flow was observed to Helen's southeast. An area of convergence was therefore formed between the southwesterlies of this anticyclone and the northerlies of Helen's circulation. At 1200 UTC 12 August, a low-level jet in this convergence area was very close to Hong Kong (Fig. 7).

Looking at the time cross section of the upper air ascents made in Hong Kong (Fig. 8), southwesterly winds of more than 40 knots were recorded at 850 hPa level during the period of the local heavy rain. The timing for the easing off of rain tied in reasonably well with the weakening of 850 hPa southwesterlies, suggesting that the 850 hPa jet to the south of Helen was one of the main contributions to the active convective development in the vicinity of Hong Kong. On the satellite picture, the cloud region over the northern part of the South China Sea also tied in reasonably well with the position of the 850 hPa jet (Fig. 9).

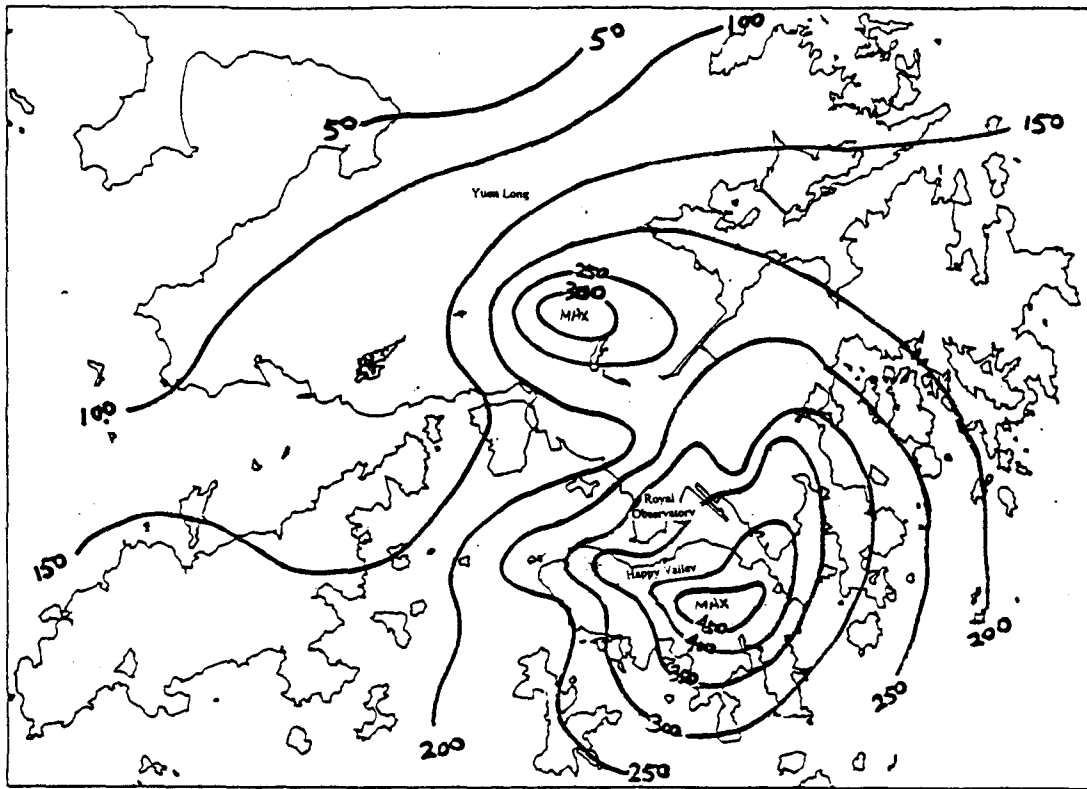
At 200 hPa level, there was a region of significant divergence close to Hong Kong at 1200 UTC 12 August, with the maximum near Ximen (Fig. 10). It is likely that this upper level divergence together with the 850 hPa jet underneath have provided the favourable environment necessary for the development of the intense meso-scale convection as observed on the radar.

5. Discussion

Looking back, Severe Tropical Storm Helen was a really hazardous storm not only because it exhibited a sharp northward turn over the South China Sea, but it also brought on disastrous heavy downpours after making landfall. Indeed, Chen and Ding (1982) have pointed out in their famous literature that for a tropical cyclone which has an anticyclone developing to its southeast, the major rain area would be in the storm's southern circulation due to convergence. Therefore, when encountering tropical cyclones exhibiting sharp northward turn like Helen, care has to be taken in monitoring the position of convergence or low-level jet and hence the possibility of heavy rain even after the storm has demised over land.

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RAINFALL DISTRIBUTION MAP. Period 950812 04:00H to 950813 04:00H

FIG. 1. Distribution of 24-hourly rainfall in Hong Kong starting 4 a.m. 12 August 1995 when the most of the heavy rain was recorded.

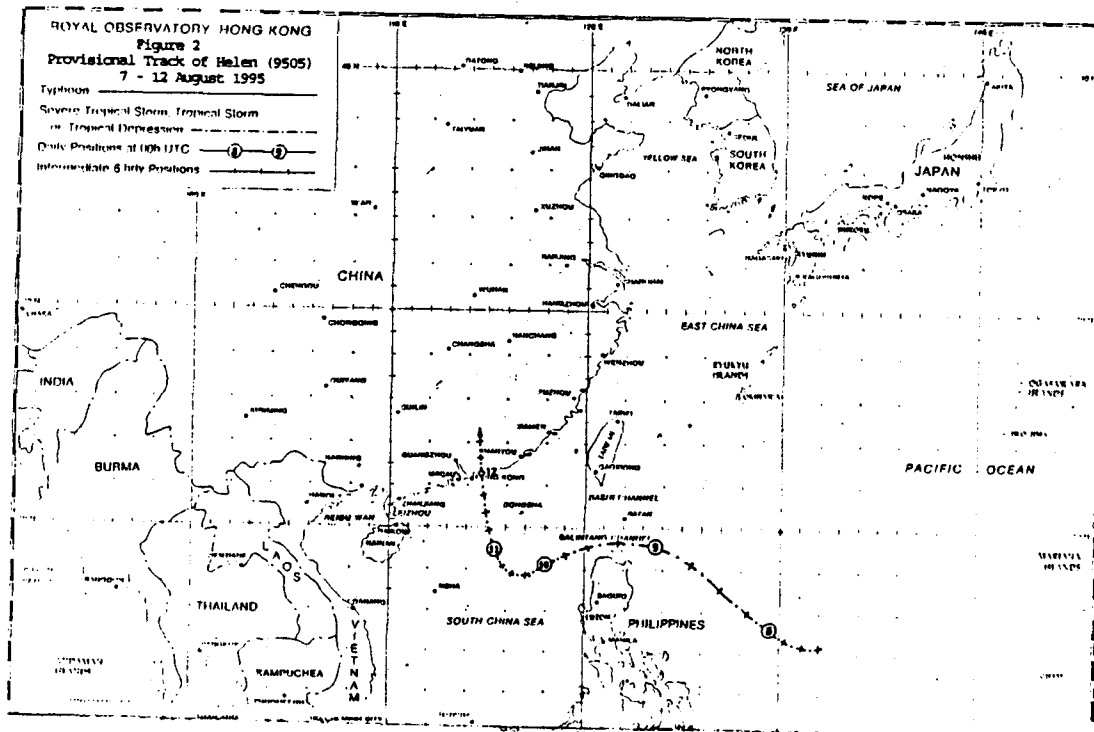


FIG. 2. Track of Severe Tropical Storm Helen of 1995.

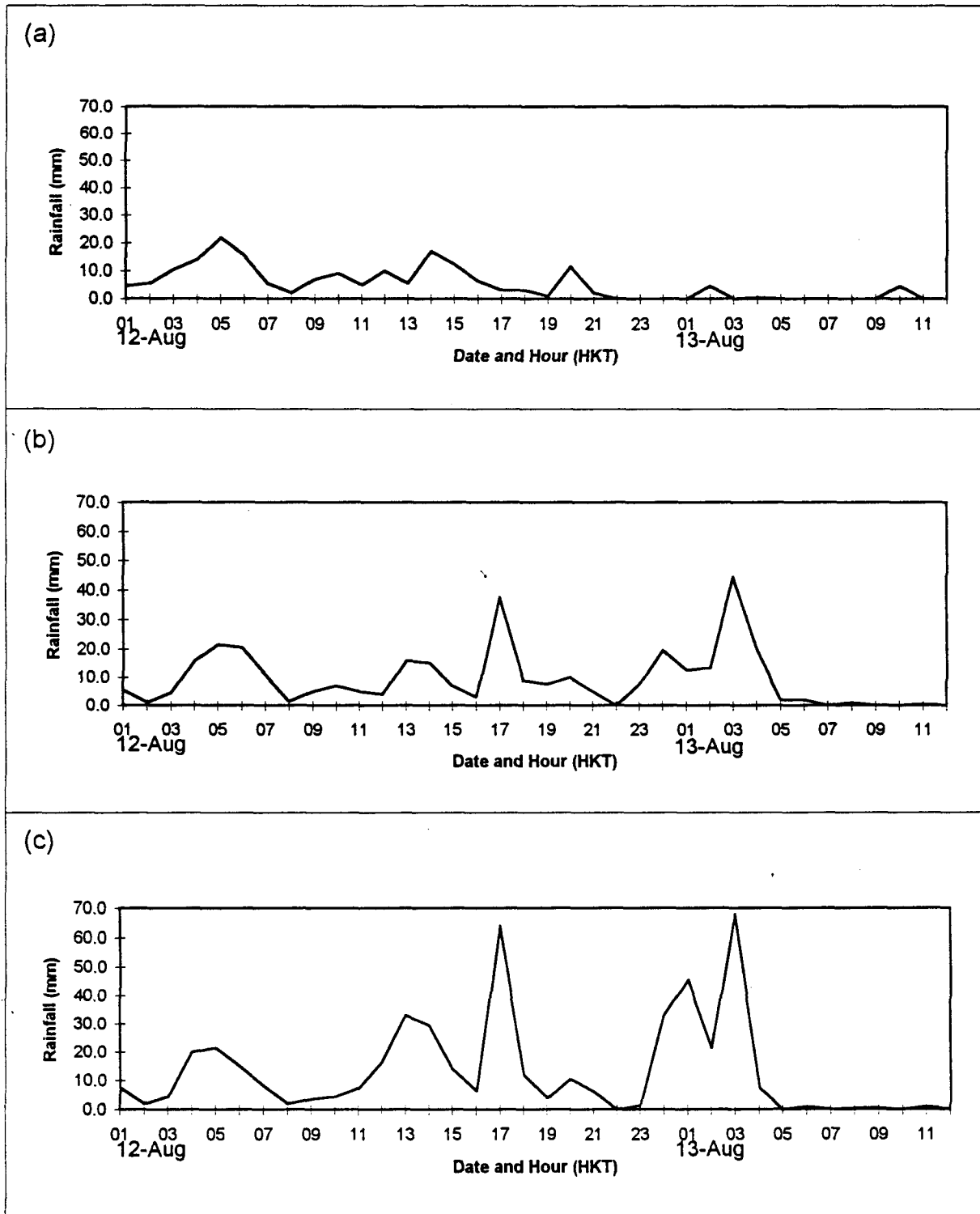


FIG. 3. Time series of hourly rainfall at (a) Yuen Long, (b) the Royal Observatory Headquarters, (c) Happy Valley from 1 a.m. 12 August 1995 to midday of 13 August 1995.

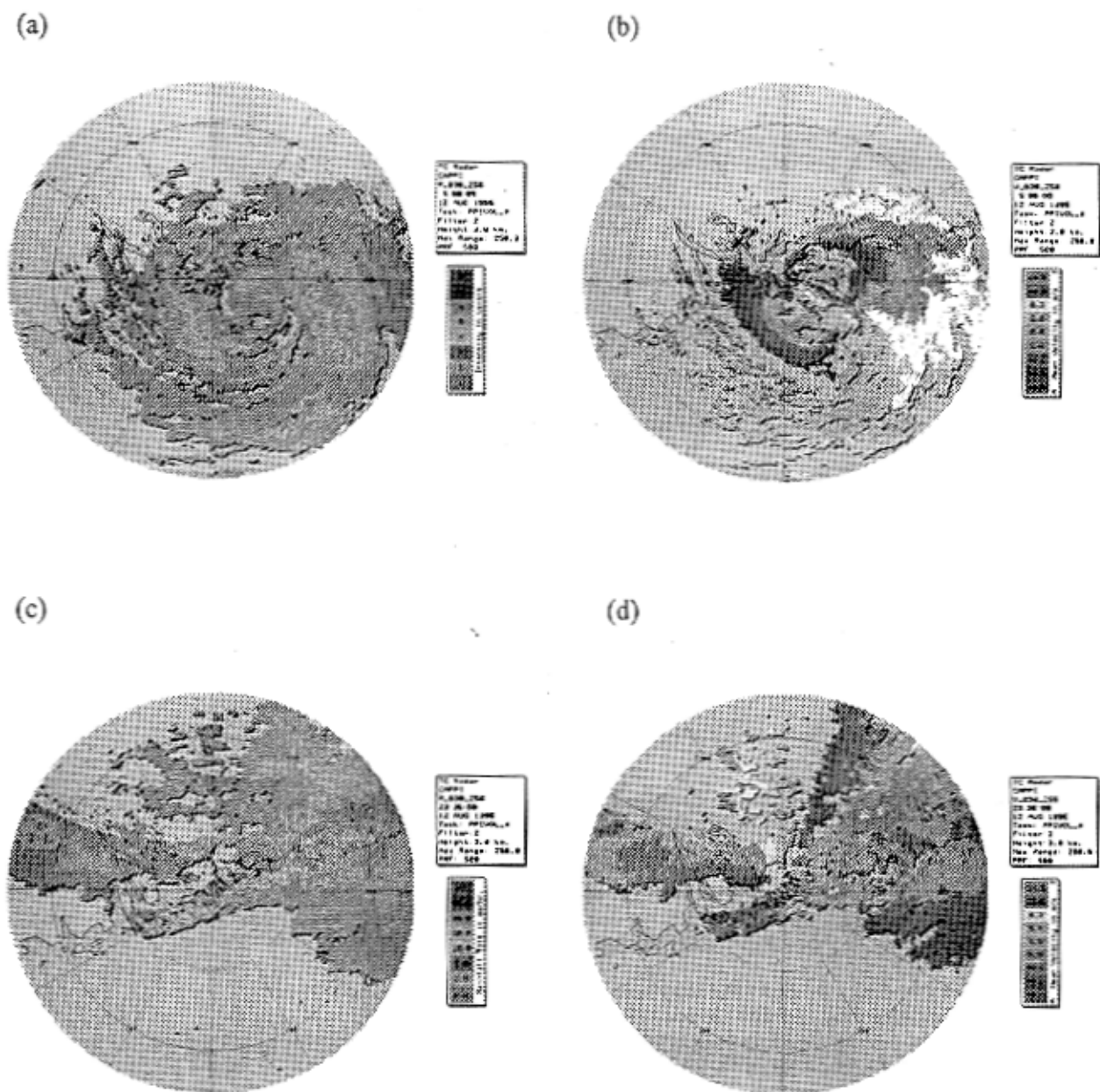


FIG. 4. 3 km CAPPI Doppler weather radar pictures over Hong Kong : (a) reflectivity and (b) velocity at 5:00 a.m. Hong Kong Time of 12 August 1995; (c) reflectivity and (d) velocity at 11:36 p.m. Hong Kong Time of 12 August 1995.

Station wind for 95081212 UTC

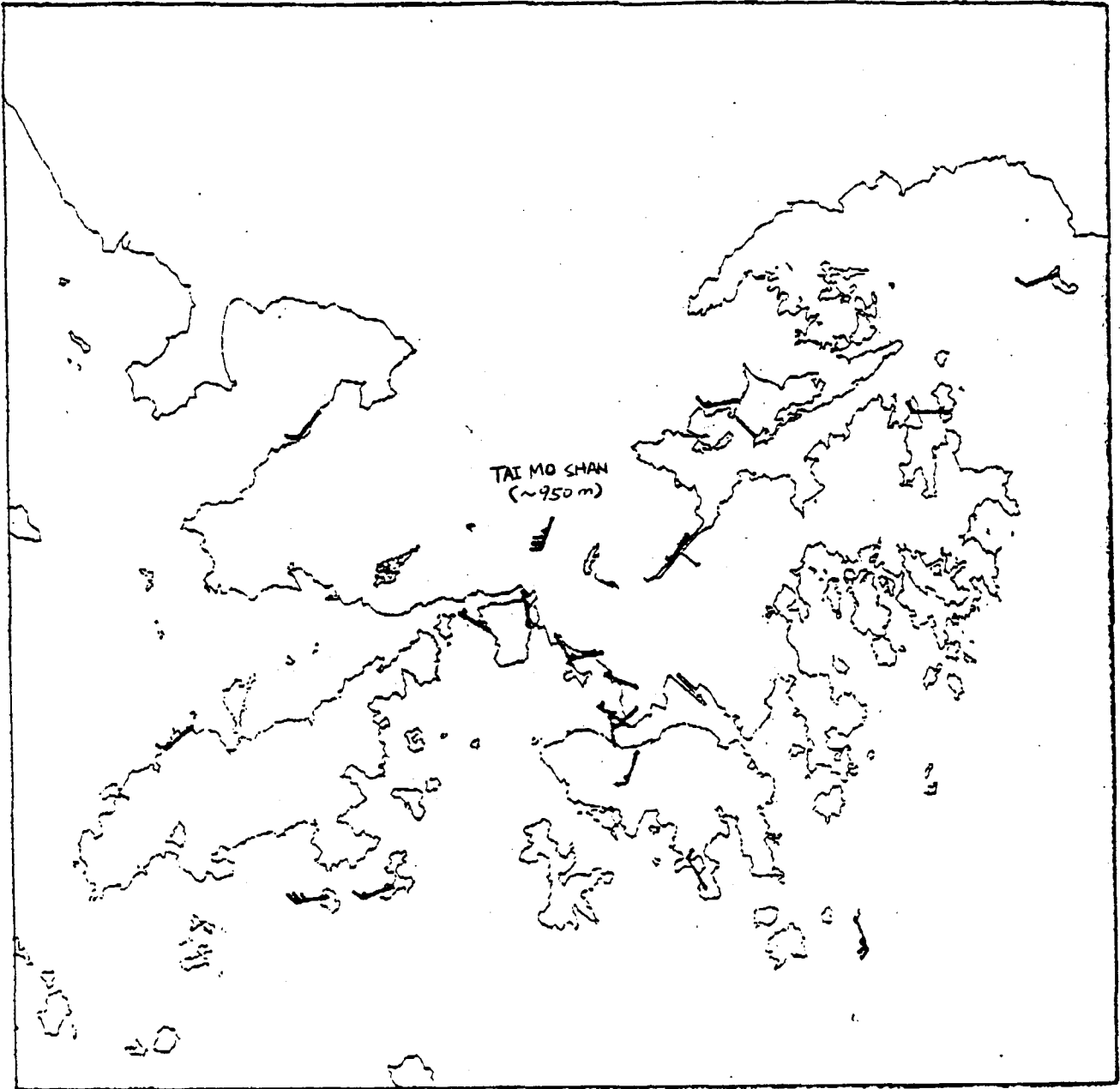


FIG. 5. 10-minute mean winds at various stations in Hong Kong at 8 p.m. of 12 August 1995.

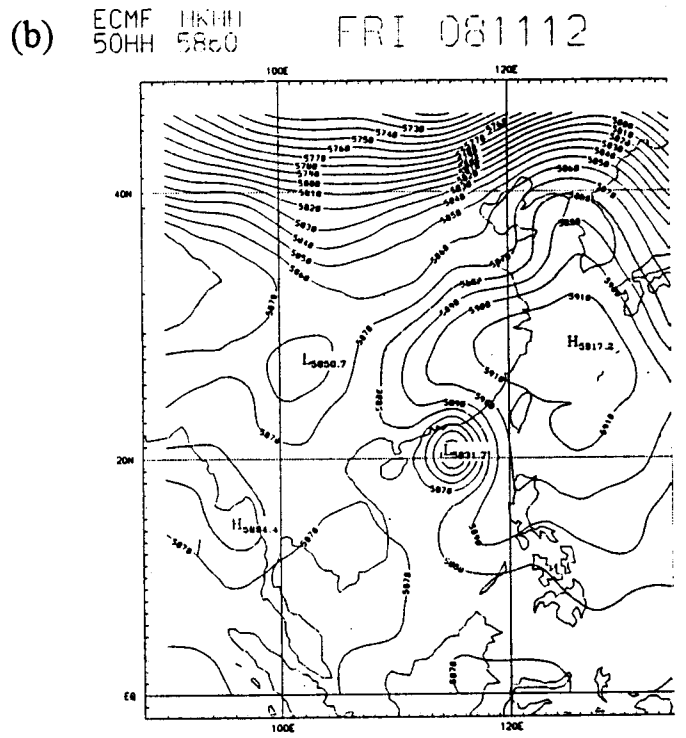
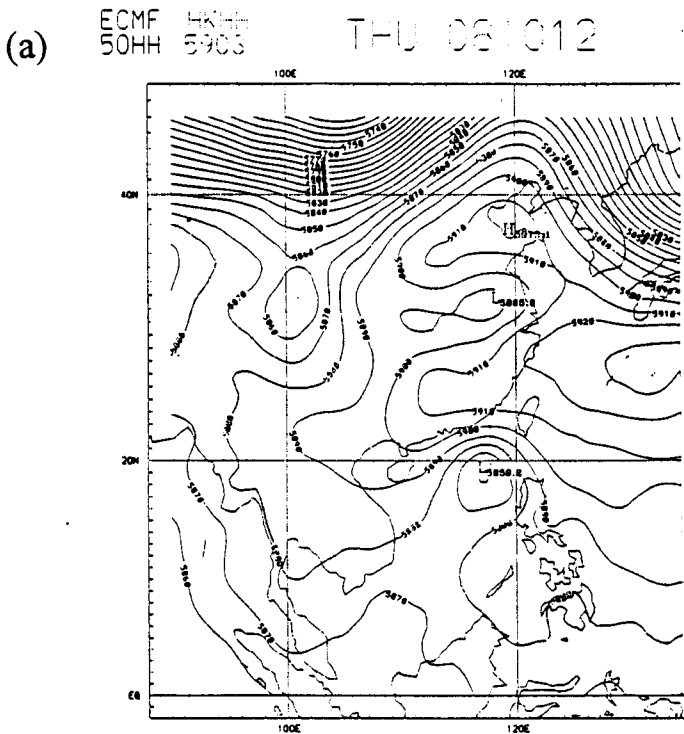


FIG. 6. 500 hPa height contour at (a) 1200 UTC 10 August 1995, (b) 1200 UTC 11 August 1995.

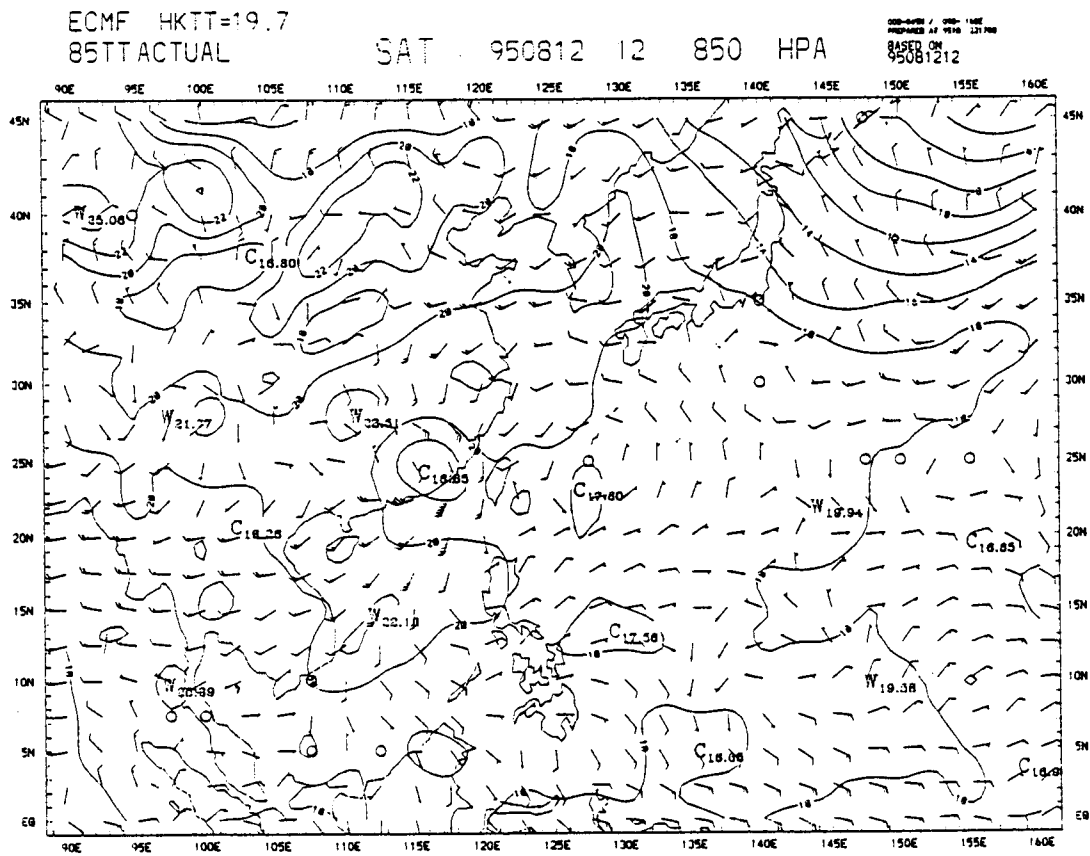


FIG. 7. 850 hPa wind field analysis at 1200 UTC of 12 August 1995. Isotherms are also shown in the diagram.

Time Cross Section (45004) from 95081112 to 95081312 UTC

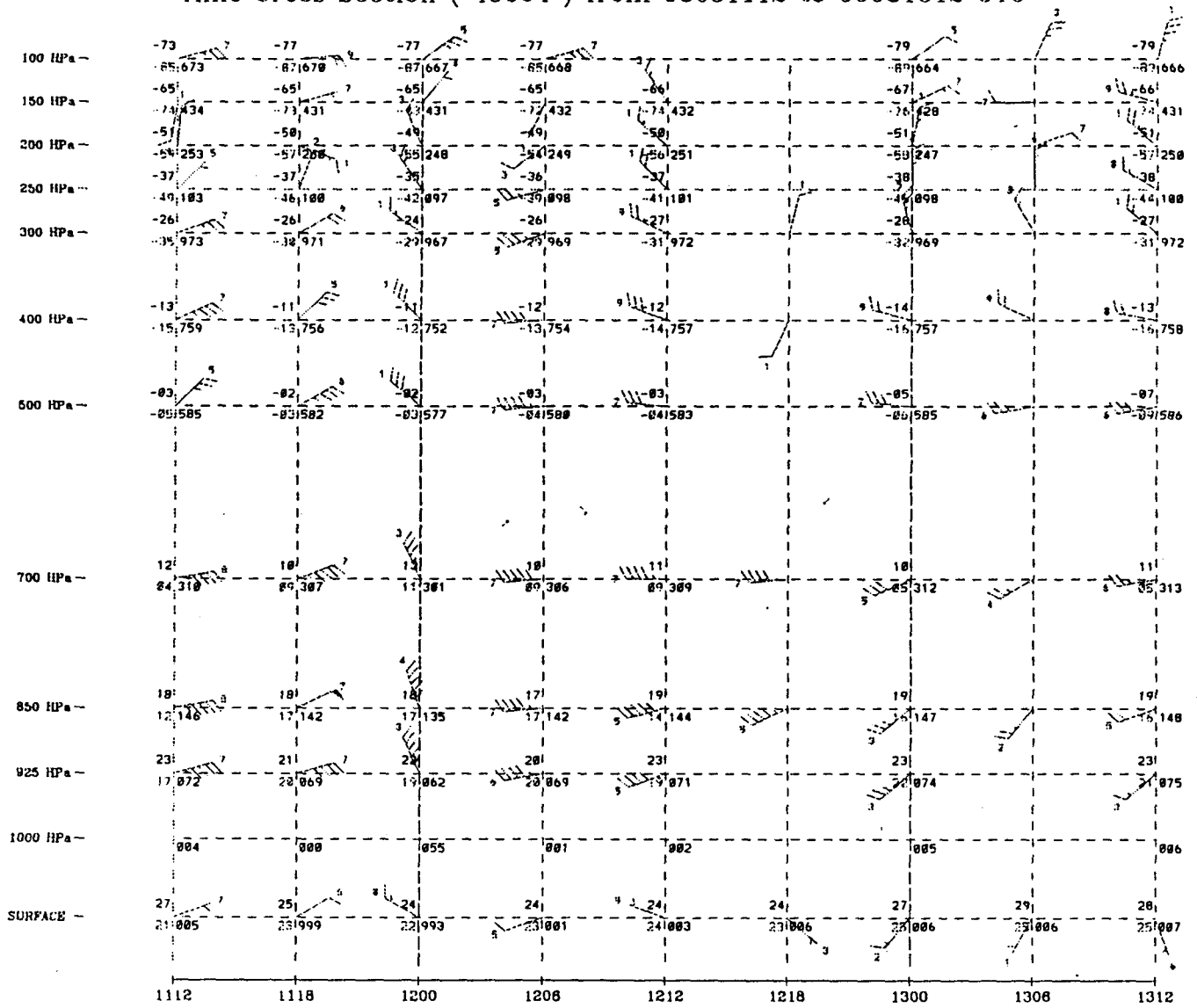


FIG. 8. Time cross section of the upper air ascents over Hong Kong from 1200 UTC of 11 August 1995 to 1200 UTC of 13 August 1995.

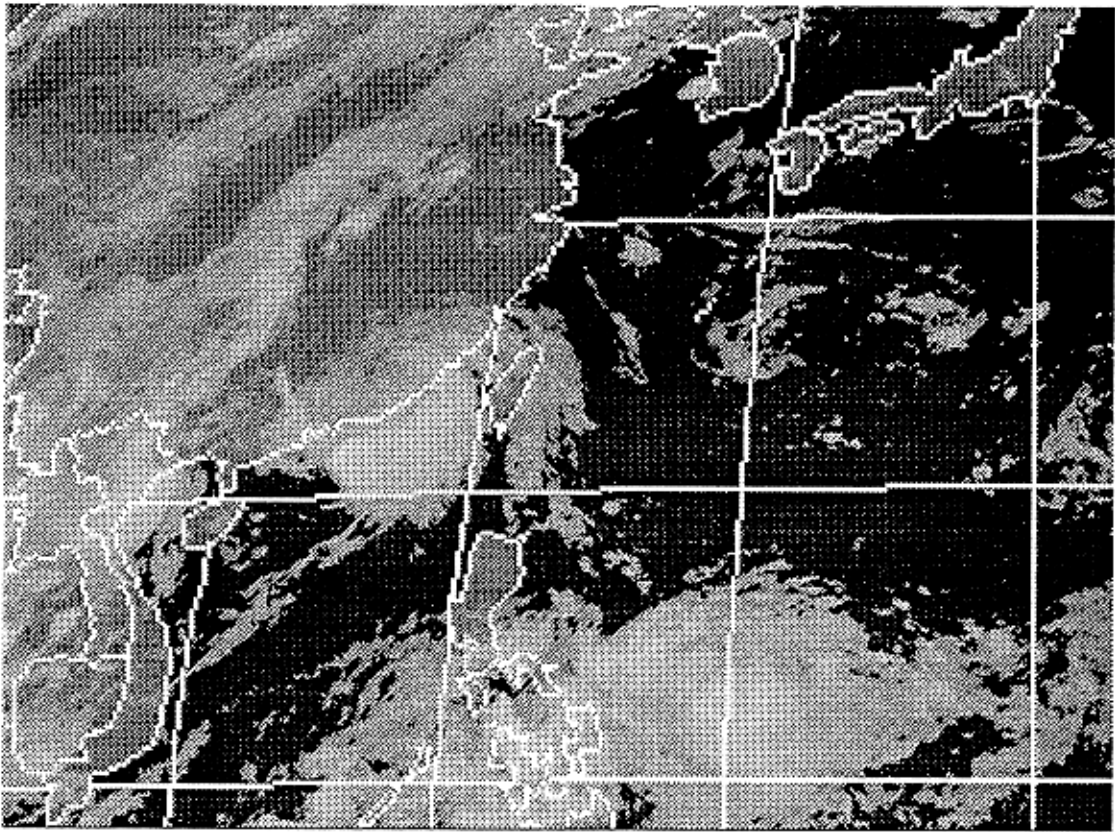


FIG. 9. GMS-5 IR satellite imagery at around midnight (HKT) of 12 August 1995.

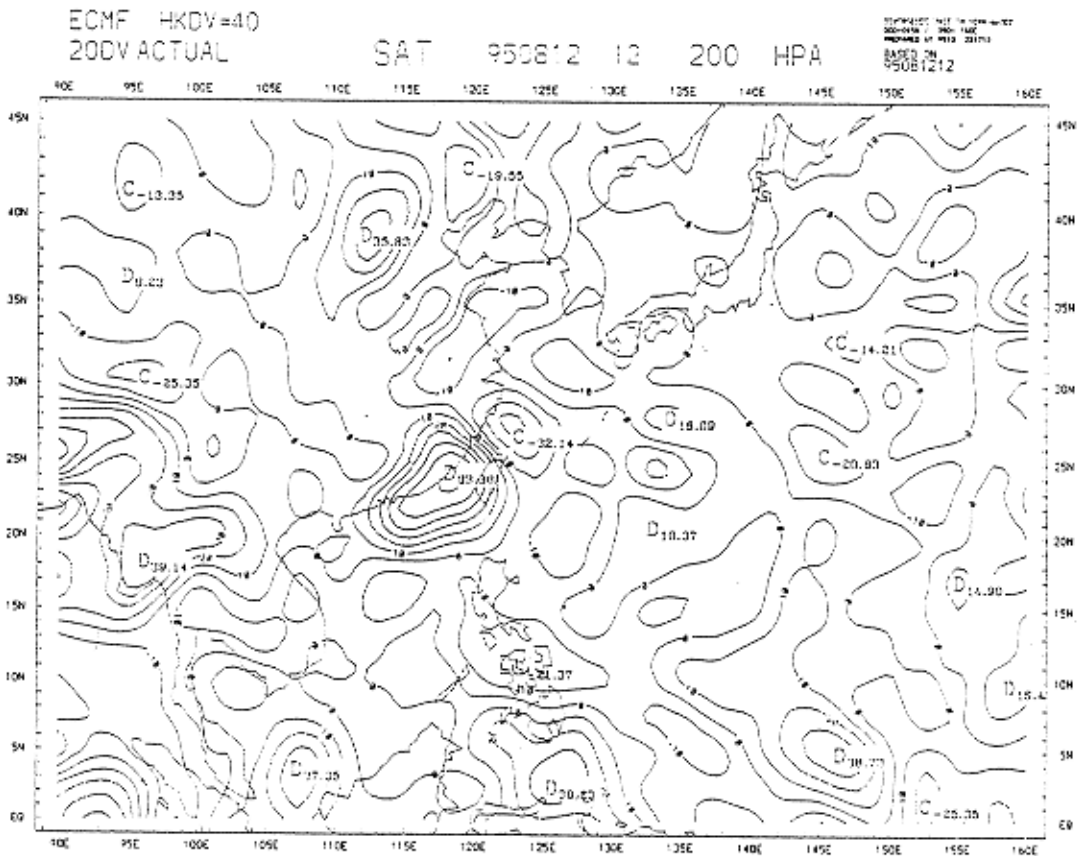


FIG. 10. 200 hPa divergence (indicated by 'D') at 1200 UTC of 12 August 1995.