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The 18 June 2000 Midget Tropical Depression over Hong Kong

John Y. K. Leung, C. C. Chan & Joly Ho

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1. Introduction

'Midget' tropical cyclones are those tropical cyclones with radii, as measured by the distance between the centre of the tropical cyclone and the outermost closed isobar, less than 2 degrees in latitude or about 200 km [Joint Typhoon Warning Centre (JTWC) 1996].

Midget tropical cyclones tend to form in association with specific synoptic patterns such as monsoon gyres (for a definition of the monsoon gyre, see Lander 1994) in the western North Pacific and are likely to strengthen and decay rapidly (Lander 2000). They are usually hard to detect because of their short life span and small physical size.

One such midget tropical cyclone, about 100 km in size, formed rapidly over the waters to the south of Hong Kong and crossed Hong Kong on the night of 18 June 2000. During the passage of the tropical cyclone, its intensity and structure were observed by the Hong Kong Observatory's dual Doppler radars and network of over 60 automatic weather stations (AWS). These observations suggest that the tropical cyclone was of tropical depression strength.

This paper describes the features of this tropical depression, addresses the operational and publicity aspects associated with the forecasting and warning of such a small and rapidly developing tropical depression, and ventures to offer a preliminary conceptual model of the midget tropical depression.

2. Synoptic Background

On 17 and 18 June 2000, an active trough of low pressure extended northeastwards from the northeastern tip of Hainan Island to a low over the northern part of the South China Sea. It then continued through northern Taiwan to another low over Japan and thence further northeastwards (Fig. 1a). The low over the South China Sea was embedded in a broad monsoon gyre. The low over Japan laid on the northern edge of the sub-tropical high.

In the lower troposphere (i.e. from the surface to 700 hPa) Hong Kong, at about 22.3°N, 114.2°E, and its vicinity were under the influence of a convective and converging southerly flow sandwiched between the monsoon gyre to the west and the subtropical ridge to the east (Fig. 1b).

In the mid-troposphere (500 hPa), a small vortex was found overland to the immediate northwest of Hong Kong (Fig. 1c). In the upper troposphere at 200 hPa, the south China coast in the neighbourhood of Hong Kong was characterized by diffluent flow, with southerly or southwesterly winds increasing north of the coastal areas (Fig. 1d).

Low level convergence associated with upper level diffluence meant the synoptic situation was one conducive for convective development.

3. Formation and Structure of the Midget Tropical Depression

a). Formation

On 18 June 2000, vortices formed and dissipated continually along the portion of the trough lying over the South China Sea. Satellite imagery (Fig. 2) showed the presence of meso-scale cloud clusters (MCC). It was likely that these vortices were meso-scale convectively generated vortices (MCVs) linked to the MCCs.

At about 9 p.m. local time (1300 UTC) on 18 June 2000, one such MCV intensified rapidly into a tropical depression over the waters to the south of Hong Kong. That cyclogenesis took place at about this time but not before was probably due in part to an enhancement in instability. This was brought about by an increase in the rate of change of equivalent potential temperature with height in the lower troposphere (Fig. 3).

The present case bore resemblance to the rapid formation of Tropical Storm Ofelia from an MCV over the western North Pacific in 1993. That intensification also took place in a convective southerly flow between a monsoon gyre and the subtropical ridge (Harr et. al. 1996).

b). Structure

The circulation and wind field of the tropical depression as captured by the Hong Kong Observatory's automatic weather station (AWS) network are shown in Fig. 4.

It can be seen that the circulation was well organized. The size of the tropical depression, as measured by the distance between the centre to the outermost closed isobar, was about 100 km (Fig. 5). The tropical depression thus could be qualified as 'very small' or 'midget' as defined by JTWC (1996).

Pressure observations suggest that the minimum pressure near the centre of the tropical depression was about 1000 hPa. Adjusting for terrain effects, the maximum sustained surface winds near the centre of the tropical depression were estimated to be about 60 km/h (10-minute mean).

JTWC (1996) has proposed a pressure-wind relation for midget tropical cyclones. It is

$$U_{max} = 17.548\,(P_n - P_c)^{0.4345} \qquad (1)$$

where U_{max} is the estimated (1-minute) maximum sustained surface winds near the centre in knots, P_n = 1010 hPa, and P_c the estimated minimum pressure.

For the tropical depression, equation (1) gives a 1-minute U_{max} of about 90 km/h or a 10-minute mean of about 80 km/h when converted by a factor of 0.9. This is an over-estimate in the case of the tropical depression.

Dual Doppler winds derived from the two Doppler radars in Hong Kong operated by the Hong Kong Observatory suggest the low level centre of the tropical depression was tilted in the general direction of northwest with height (Fig. 6). The horizontal displacement was about 50 km over a depth of 5 km.

Radar reflectivity (Fig. 7) shows that the rainfall rates associated with the tropical depression were mainly 30 mm/h or less. During the passage of the tropical depression, less than 10 mm of rainfall were recorded generally over Hong Kong.

A conceptual model of the tropical depression is shown in Fig. 8. It is reminiscent of the structure of the MCV analyzed by Yu and Juo (1999) using airborne dual Doppler radar observations. That MCV also had a centre which tilted north-northwestwards with horizontal displacement of greater than 50 km in a depth of 6 to 7 km. In their case the MCV had a lifetime of more than 24 hours, but did not deepen into a tropical cyclone.

4. Operational aspects

The tropical depression was already monitored while as an MCV during the afternoon of 18 June 2000. That cyclogenesis had taken place that night was detected by the Observatory's Doppler radar, which at 9 p.m. local time (1300 UTC) showed a circulation with a maximum wind of about 55 km/h (Fig. 9). Huangmao Zhou, an AWS about 55 km to the south-southwest of Hong Kong built jointly with the Guangdong Meteorological Bureau in mid 1985, also reported winds of about 52 km/h.

It is unusual for a tropical depression to form so rapidly and so close to land. This proximity, and with fixes suggesting that the tropical depression would move northwards with a forward speed about 30 km/h, meant that the tropical depression would very soon sweep through and bring strong winds to Hong Kong.

In consideration of public safety, the Strong Wind Signal No. 3, was hoisted directly without being preceded by the Standby Signal No. 1 as would normally be the case under the Observatory's graded tropical cyclone warning system.

Following its formation the tropical depression was tracked continuously by the Observatory's Doppler radars and AWS network. The community was kept informed of the situation through hourly updates via the media and the Observatory's homepage.

The tropical depression crossed Hong Kong from south to north, maintaining its intensity. It entered Guangdong just before 11 p.m. local time (2300 UTC) on the morning of 19 June 2000. It then dissipated and the Strong Wind Signal No. 3 was lowered. During the passage of the tropical depression, warnings were in force for duration of 4.5 hours, the shortest on record for Hong Kong.

The track of the tropical depression is shown in Fig. 10. A summary of the passage of the tropical depression can be found in the Monthly Weather Summary for June 2000 published by the Hong Kong Observatory (2000).

5. Publicity Aspects

The direct hoisting of the Strong Wind Signal No. 3 is a rare event in Hong Kong. The last time it happened was in September 1959, during the passage of Tropical Storm Nora.

The community therefore needed to be fully apprised to enable them to take the necessary actions and to prevent undue alarm. To this end a briefing session was immediately held for the media following the hoisting of the No. 3 signal. During the session the media was thoroughly briefed on the history of the tropical depression, the rationale for the direct hoisting of the Strong Wind Signal No. 3, the forecast movement of the tropical depression and impact on local weather, prognosis on the likelihood of higher signals, and advice on the precautions to take.

Both the Observatory's dial-a-weather service and homepage were flooded with over 100 000 enquiries on 18 June. This bespeaks of the usefulness of information technology in helping to deliver information, easing the forecaster's burden.

One natural question asked by the media was the likelihood of a higher signal, that is, the gale signal, being hoisted directly. Apprehension was allayed by describing the environmental conditions required for the further deepening of the tropical depression and explaining that these conditions were not present at that time.

Further interviews were conducted the next day (19 June) to provide additional details and to serve as a wrap up. These initiatives were well received.

The rapid provision of information through different channels minimized damage, and with the public's co-operation allowed a possible panic to be avoided. It underlined the importance of keeping the public fully informed in a situation such as that encountered.

6. Conclusions

An MCV deepened into a tropical depression near Hong Kong on the evening of 18 June 2000. This was a midget tropical depression with a size of about 100 km. The usefulness of Hong Kong Observatory's Doppler radars and the AWS network was amply demonstrated in the detection and monitoring of the midget tropical depression. In particular, dual Doppler winds suggest that the centre of this tropical depression was tilted to the northwest. The horizontal displacement was about 50 km through a vertical depth of 5 km. The lifetime of this tropical cyclone was about 5 hours.

Despite the direct hoisting of the Strong Wind Signal No. 3, damage was minimized and possible panic pre-empted. This was achieved by a strategy of keeping the public fully informed in a timely manner. Information technology also played an important role in placing the latest information at the disposal of the public.

Acknowledgements

Our colleagues Dr. C.M. Cheng made available the dual Doppler radar data, Mr. Y. Chen and Mr. K.L. Kwan prepared the figures and Dr. W.L. Chang helped with useful comments. Their assistance is gratefully acknowledged.

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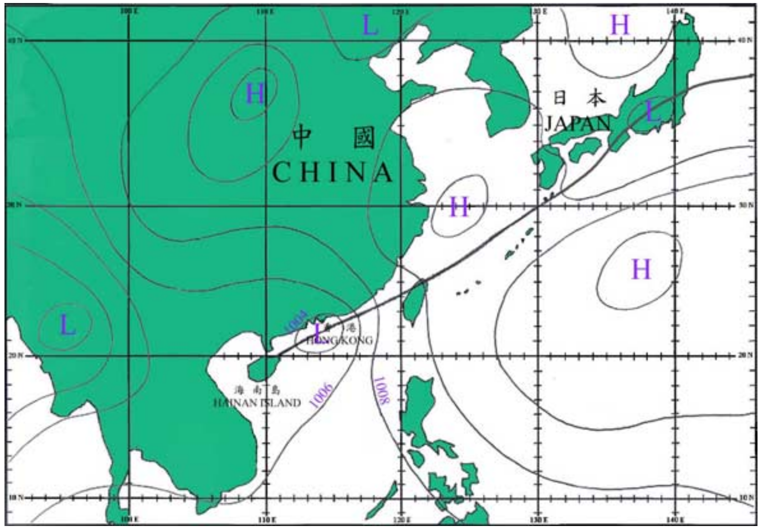


Figure 1a Surface weather chart at 1200 UTC (8:00 p.m. local time) on 18 June 2000.

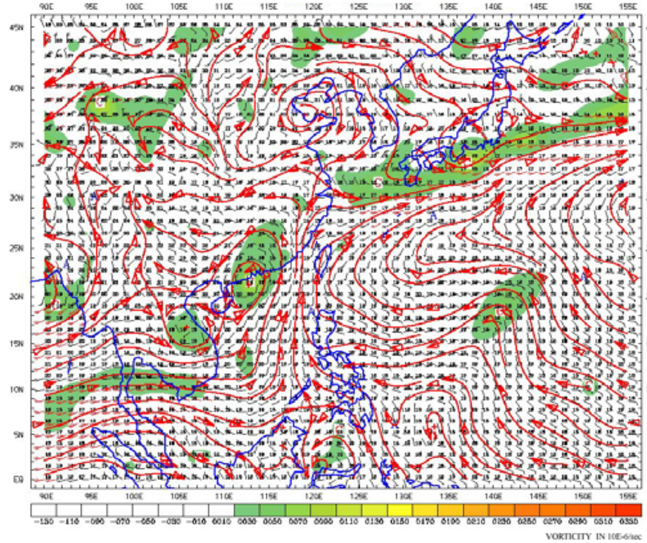


Figure 1b 850 hPa winds and vorticity valid at 1200 UTC (8:00 p.m. local time) on 18 June 2000 (based on Japan Meteorological Agency's analysis).

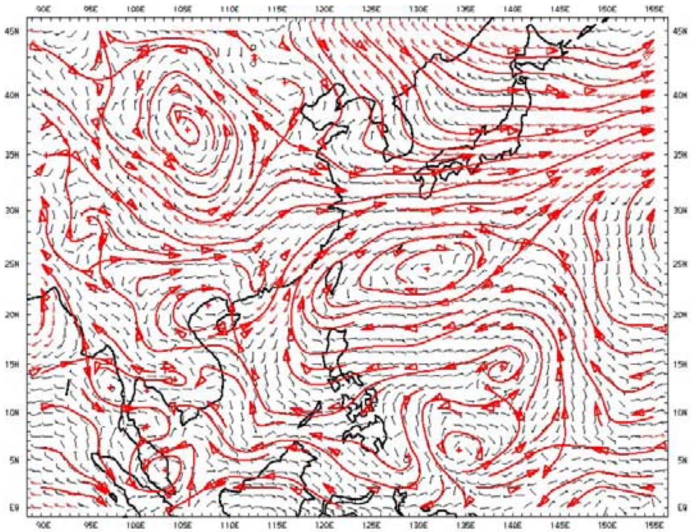


Figure 1c 500 hPa winds valid at 1200 UTC (8:00 p.m. local time) on 18 June 2000 (based on Japan Meteorological Agency's analysis).

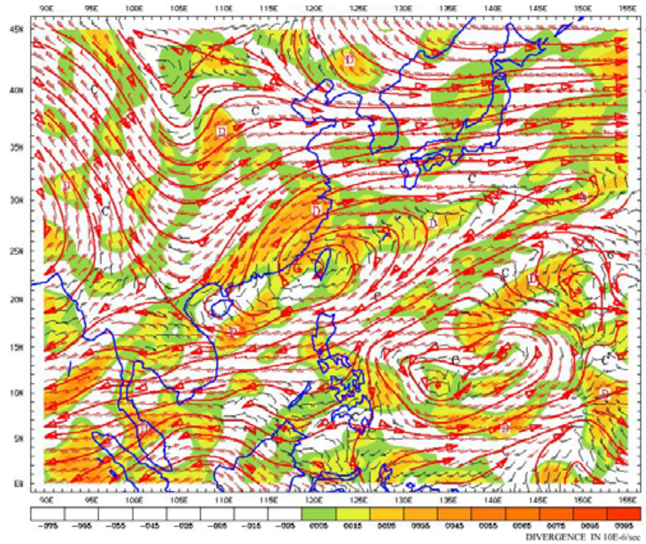


Figure 1d 200 hPa winds and divergence valid at 1200 UTC (8:00 p.m. local time) on 18 June 2000 (based on Japan Meteorological Agency's analysis).

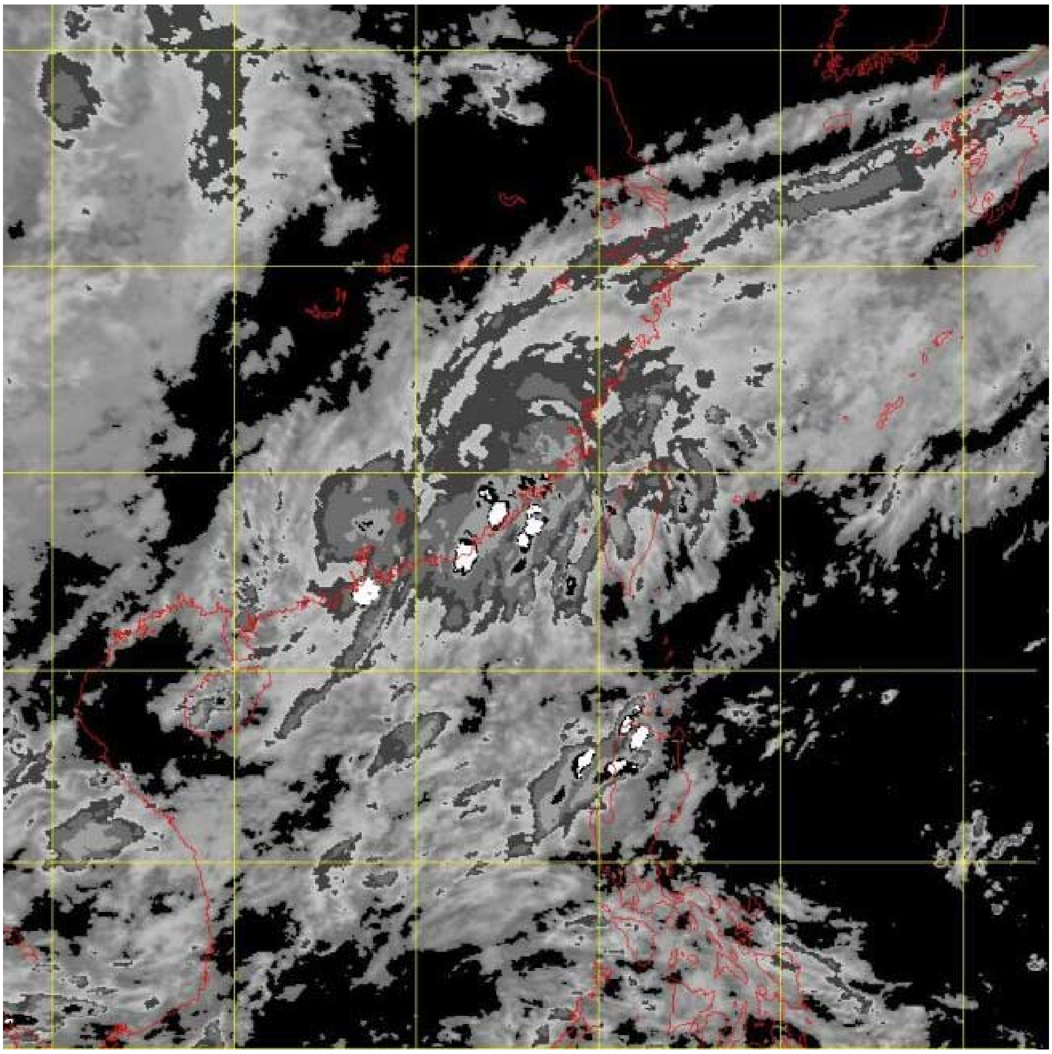


Figure 2 Enhanced infra-red satellite imagery of the MCC at around 1230 UTC (8:30 p.m. local time) on 18 June 2000. The imagery is from GMS-5.

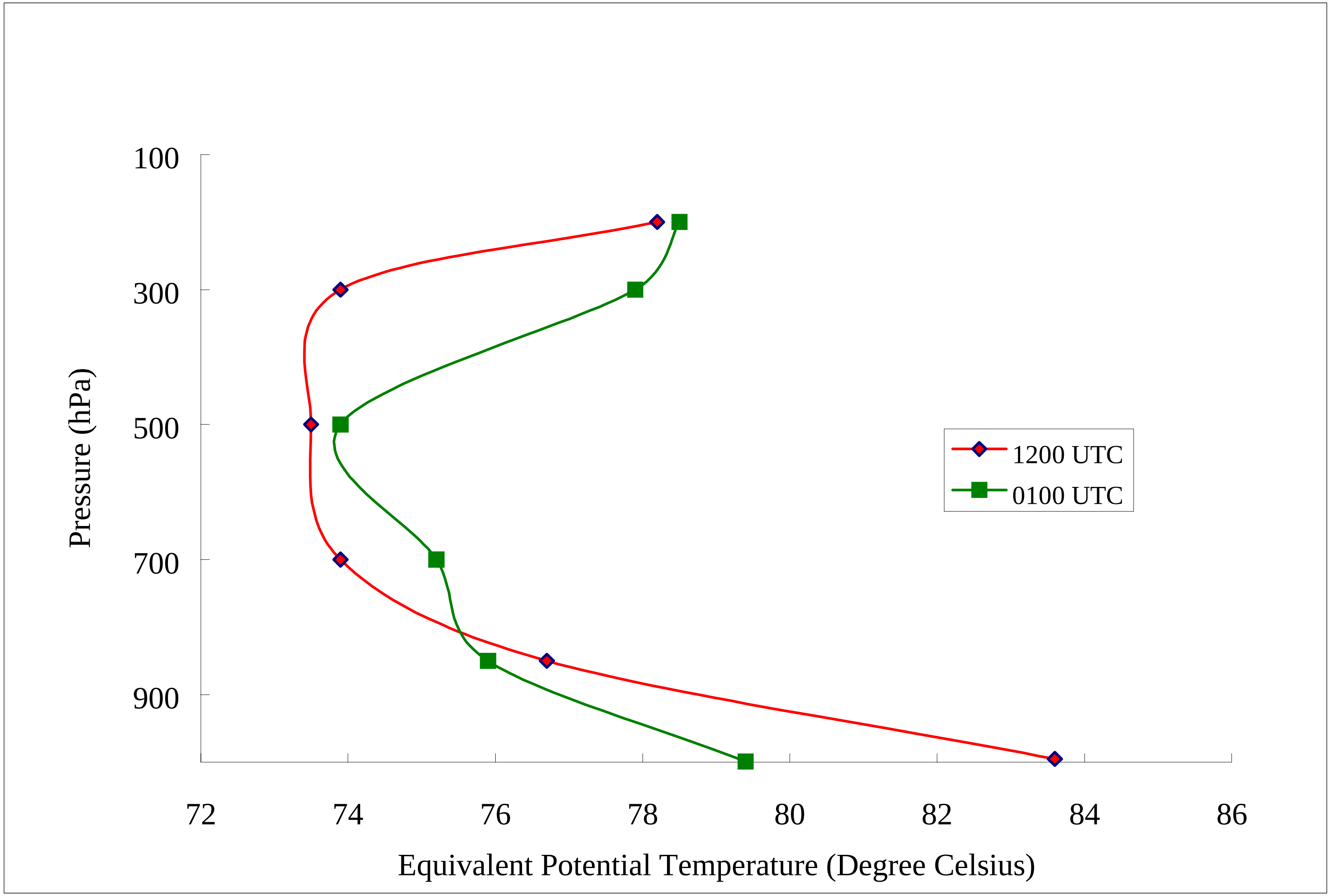


Figure 3 Equivalent potential temperature versus pressure at 0100 UTC and 1200 UTC (9:00 a.m. and 8:00 p.m. local time) on 18 June 2000.

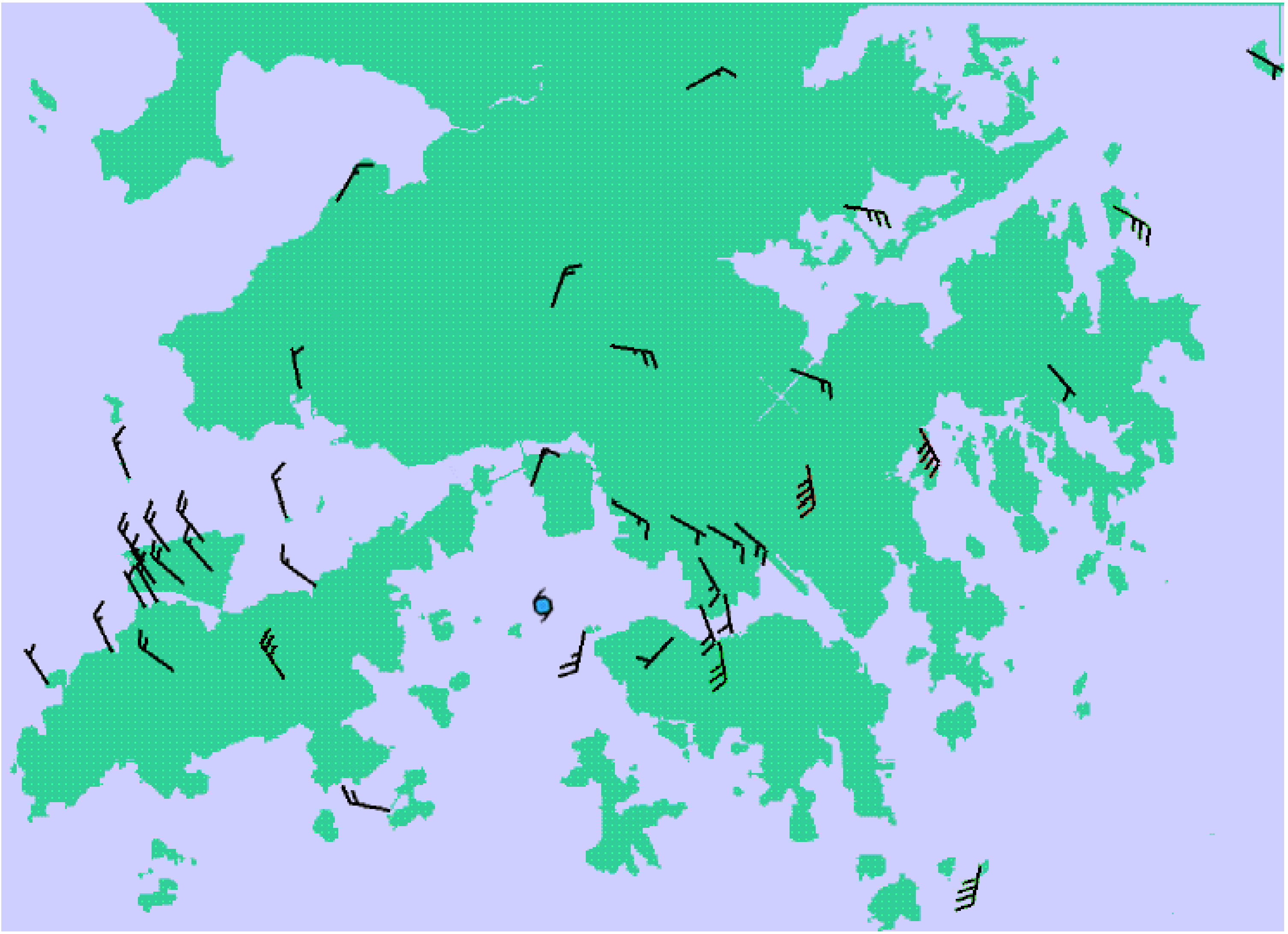


Figure 4 Winds recorded by the Hong Kong Observatory's automatic weather station network at 1400 UTC (10:00 p.m. local time) on 18 June 2000 showing the circulation of the tropical depression at that time.

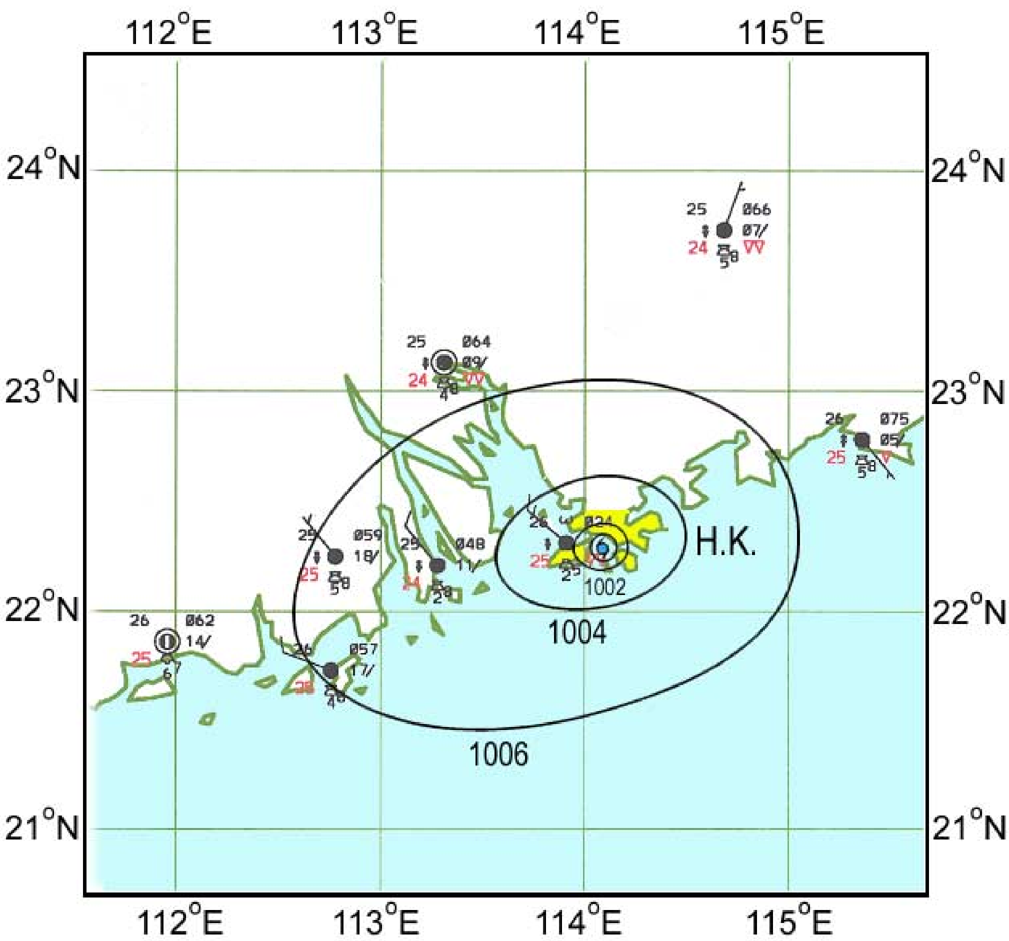
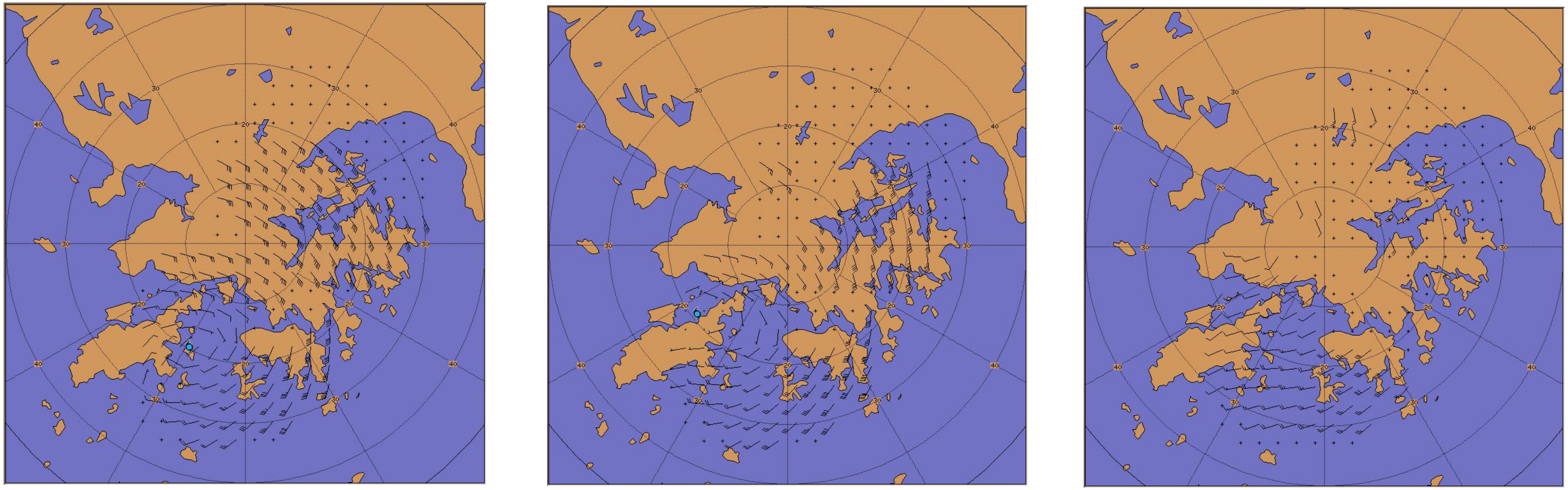


Figure 5 Surface observation at 1400 UTC (10:00 p.m. local time) on 18 June 2000 over Guangdong area.



(a) (b) (c)

Figure 6 Dual Doppler wind fields at the height of (a) 1.5 km, (b) 2.5 km and (c) 5.0 km derived from the two Doppler radars at Tai Mo Shan and Tate's Cairn in Hong Kong. The centre of the tropical depression at 5.0 km, as determined from both dual Doppler and upper air soundings, is just off the left hand margin of Figure 6(c).

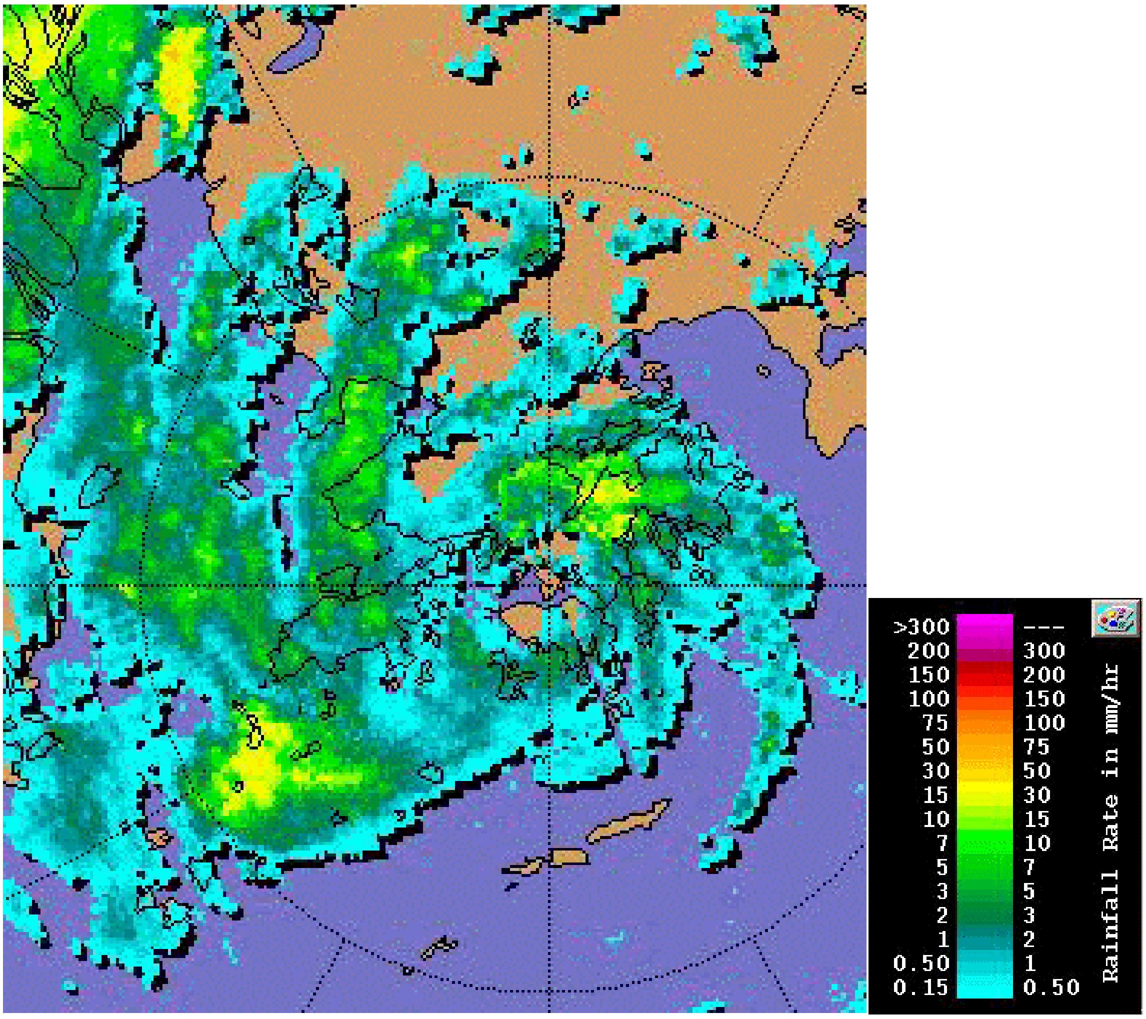


Figure 7 Radar reflectivity picture showing the precipitation pattern at 1330 UTC (9:30 p.m. local time) on 18 June 2000.

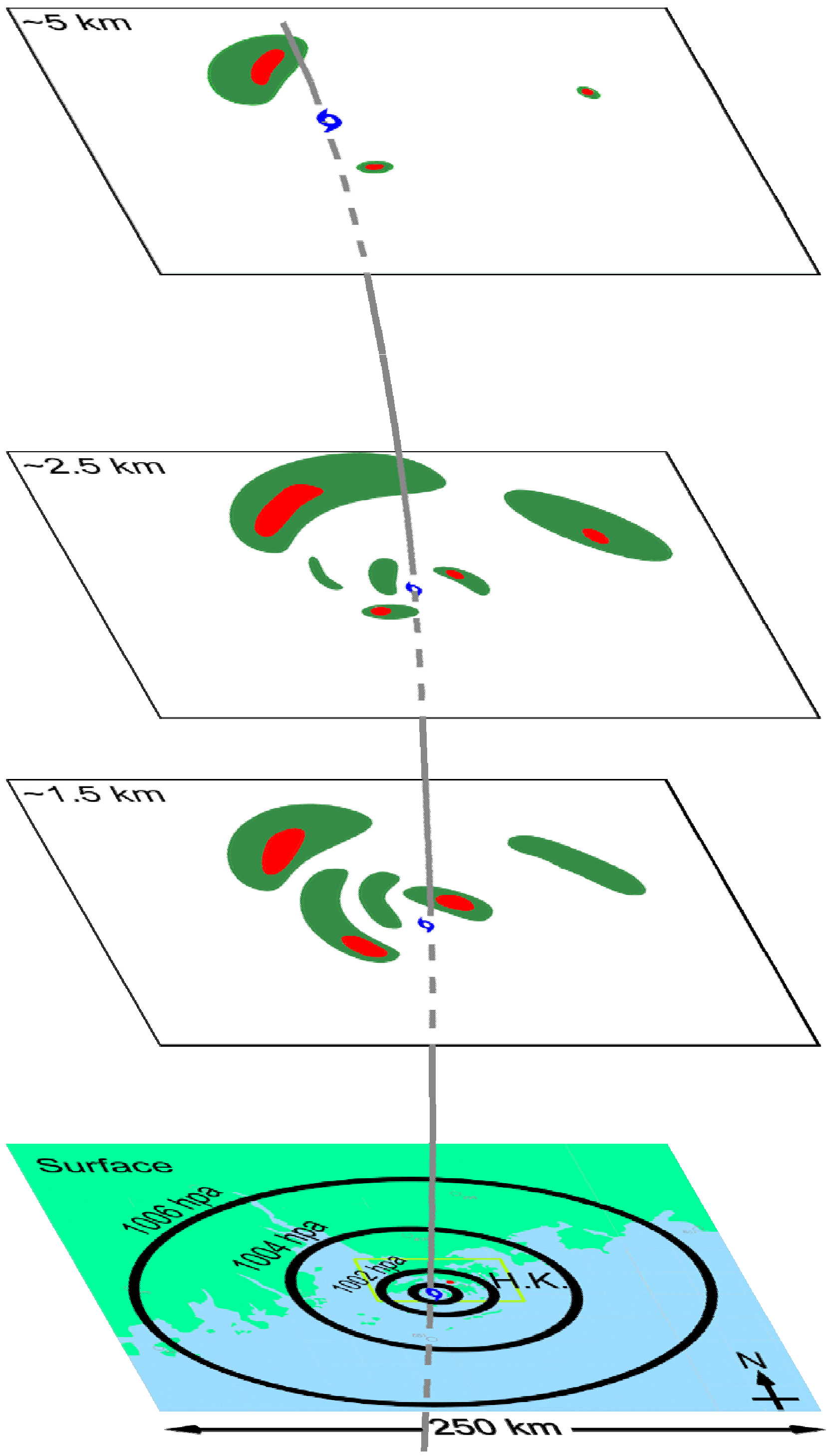


Figure 8 A conceptual model of the midget tropical depression. Dark contours at the surface are isobars. Coloured areas at 1.5, 2.5 and 5 km are areas of maximum rainfall intensity. Green represents a rainfall rate of less than 10 mm/h, red 10 to 30 mm/h.

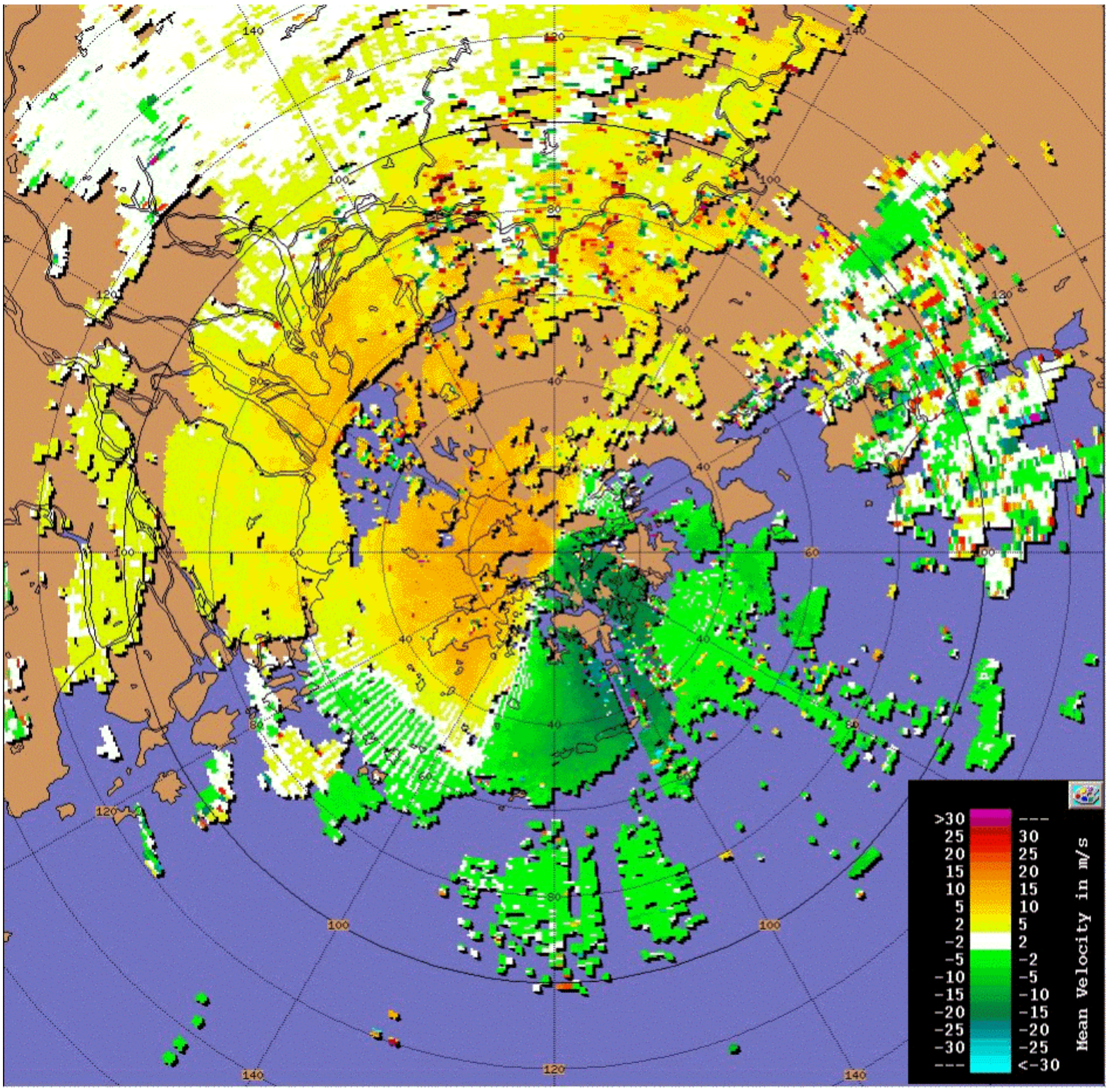


Figure 9 Doppler radar winds for the tropical depression at 2100 UTC (9:00 p.m. local time) on 18 June 2000. The legend is shown in the bottom right hand corner. Positive values in the legend represent radial velocities away from the radar site, and negative values towards.

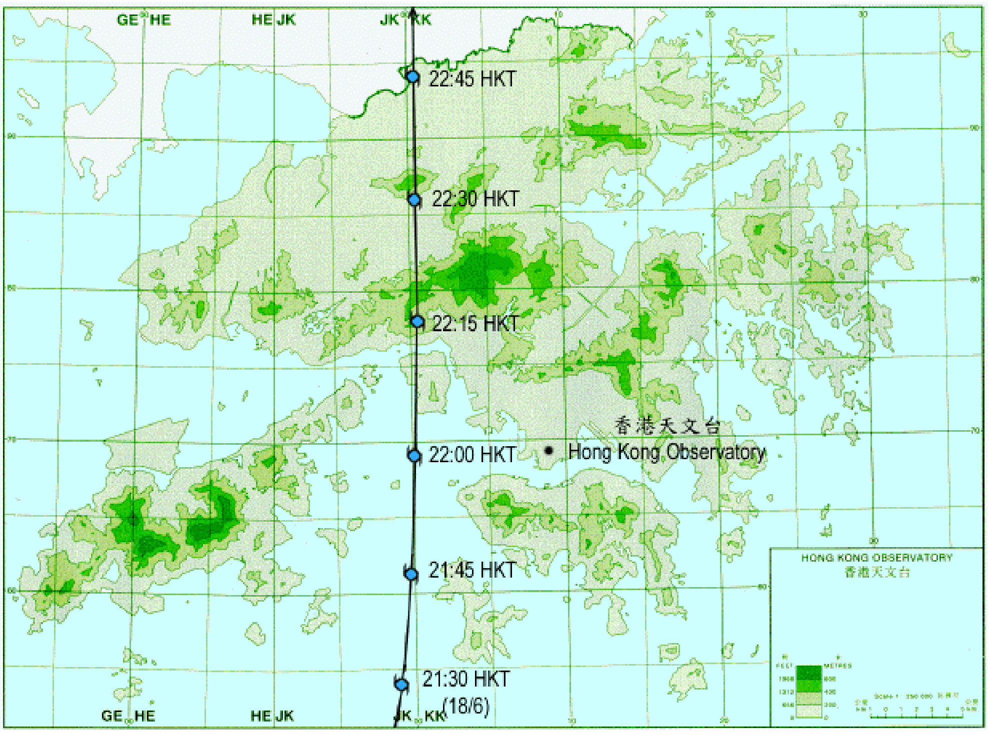


Figure 10 Track of the tropical depression as it crossed Hong Kong. The letters HKT marked along the track stands for local time which is 8 hours ahead of UTC.