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Tropical cyclones and aircraft operations in Hong Kong

(by Staff of the Royal Observatory, Hong Kong)

Hong Kong is frequently affected by tropical cyclones which form in the South China Sea or the western North Pacific (see R.O. publication "Typhoon!" 1971). They generally move in a west-northwesterly direction at a speed of about five to twelve knots but occasionally, they may recurve to the south of Hong Kong and reach us from a southerly or even south-westerly direction (see Figure 1 and Chin 1972). On the average, there are about six tropical cyclones per year that come sufficiently close to Hong Kong and necessitate the hoisting of local tropical cyclone warning signals. About two of these per year cause gales at the Royal Observatory.

When Hong Kong is under the threat of an approaching tropical cyclone, airline operators and pilots need to have up-to-date meteorological information for making decisions on matters such as the changing of flight schedules, the deployment of aircrew and the protection of aircraft. They all have the same questions in mind: "Where is the centre now? What is the intensity? What is the predicted movement? How close will it come to Hong Kong? How far away is it necessary to detour inbound or outbound flights from the normal routes to avoid severe icing and turbulence or adverse winds? Can I bring in the aircraft now and get it out in time? etc. etc.?" Answers to these questions are normally available at the Airport Meteorological Office where aviation forecasters keep continuous watch on developments and issue SIGMETs at regular intervals. In these SIGMETs, the intensity and position are given, together with the predicted movement and intensity change and a 24-hour forecast position. The Hong Kong's area of responsibility for warning tropical cyclones is : 10N to 30N and 105E to 125E. In 1975, the mean error for 24-hour forecast positions is about 100 nautical miles. SIGMET information is also broadcast over the VOLMET.

The most critical stages of aircraft operations, from the safety point of view, are the take-off and landing phases. In Hong Kong, the runways are orientated northwest-southeast, and since the majority of tropical cyclones which affect Hong Kong approach from the southeast, the surface winds at the Airport are basically across the runways, thus rendering the landing and take-off operations much more hazardous. In tropical cyclone conditions, the surface visibility is generally poor and the runways are slippery because of the heavy squally showers or rain.

In tropical cyclones, the surface winds as well as the low-level vertical and horizontal wind shears are large and severe turbulence is usually present. The turbulence is accentuated at Hong Kong Airport by the hills surrounding the aerodrome. In a recent incident, a jet aircraft was virtually lost out of sight from the control tower for a few seconds when it was forced to assume a low profile climb after take-off on Runway 31 in Hong Kong Airport under strong northerly wind conditions. The Captain had to abandon climb in favour of speed in order to control the aircraft due to excessive wind shear and turbulence. In Hong Kong, under the influence of a tropical cyclone, the vertical wind shear between 200 and 1000 feet from the ground can exceed 25 knots and the surface horizontal wind shear in excess of 10 knots between the southeast and northwest anemometers is not uncommon.

Due to the presence of bands of convective clouds and to friction, the surface winds in tropical cyclones are squally and gusty. For winds from an easterly direction with a speed of 20 knots, the gust factor is about 1.84 for the 31 touch-down and 2.03 for the 13 touch-down (see Chen 1975). This means that when the surface winds are blowing from the east with a speed of 20 knots, the peak gust is about 37 knots at the southeast end of the runway and 41 knots at the northwest end. For winds of 40 knots from the same direction, the peak gust for the southeast end should be about 66 knots (gust factor 1.65) and that for the northwest end 73 knots (gust factor 1.83).

The highest mean surface wind speed and gust at Hong Kong Airport since 1960 are 66 knots and 110 knots respectively. With a tropical cyclone approaching from the southeast, on the average, the onset of strong surface winds in Hong Kong occurs when the centre is about 180 nautical miles away and gales start blowing when it is at a distance of around 80 nautical miles. The mean duration of gale force winds caused by tropical storms, severe tropical storms and typhoons at the Royal Observatory based on 86 years of record is 6.7 hours with a maximum of 27 hours. For tropical cyclones approaching from the southeast, measurable rain normally spreads into Hong Kong when the centre is about 250 nautical miles from Hong Kong. The onset of almost continuous rain can be expected when it is about 180 nautical miles away.

The circulation of a tropical cyclone at the surface covers an area with a diameter sometimes reaching 1000 nautical miles and the clouds in the convective region extend to over 40000 feet. Yet the portion with heavy weather is only about 400 nautical miles across at the normal cruising levels of jet aircraft (see Figure 2). Severe icing and turbulent conditions caused by violent updrafts, wind shear and gustiness may exist within about 200 nautical miles from the centre, especially when the aircraft is passing through a spiral rain band of the tropical cyclone. These spiral rain bands can be detected by radar and hence also the rain-free eye at the centre. Extreme care must be exercised when estimating the position of the eye of a tropical cyclone especially when it is outside the scope of the PPI, since such determination affects the choice of optimum flight level and route for the evasion of the heavy weather. Thunderstorm activity and hail have been reported by aircraft but not very frequently. Heavy rainfall occurs in the rainbands and this has been known to cause trouble in propeller aircraft due to excessive cooling of the engines. Rainfall rates of over 500 mm/h have been recorded at Hong Kong.

Winds in a mature typhoon are strongest at about 1000 ft. and fall off with height above about 5000 ft. At 40,000 ft. they will be blowing cyclonically (anticlockwise) around the eye at about 30 to 50 knots but at a distance from the centre of about 200 nautical miles they will be blowing radially outwards and beyond that they will be blowing anticyclonically.

In the eye and inner convective regions of a typhoon, the air temperature at 30 to 40 thousand feet is higher than that of the surrounding environment by about 10 C. Pilots should be aware that inside this region, the aerodynamic performance of the aircraft and engines will be reduced.

Apart from data received from weather satellites, radar, reconnaissance aircraft, ships and land stations, the Hong Kong Royal Observatory depends also on civil aircraft for supplying reports on tropical cyclones: the location of the radar eye, the flight level wind - especially from Doppler or I.N.S. equipment - and temperature and any significant weather. These aircraft meteorological reports are highly valuable and should be transmitted without delay to the Airport Meteorological Office. However, care should be taken to positively identify the radar eye and to give its position accurately; it is sometimes possible to see "false eyes" on radar formed by the chance juxtaposition of rain areas around a relatively clear area. It is useful to verify that the flight level winds are in agreement with an eye at the reported location.

References

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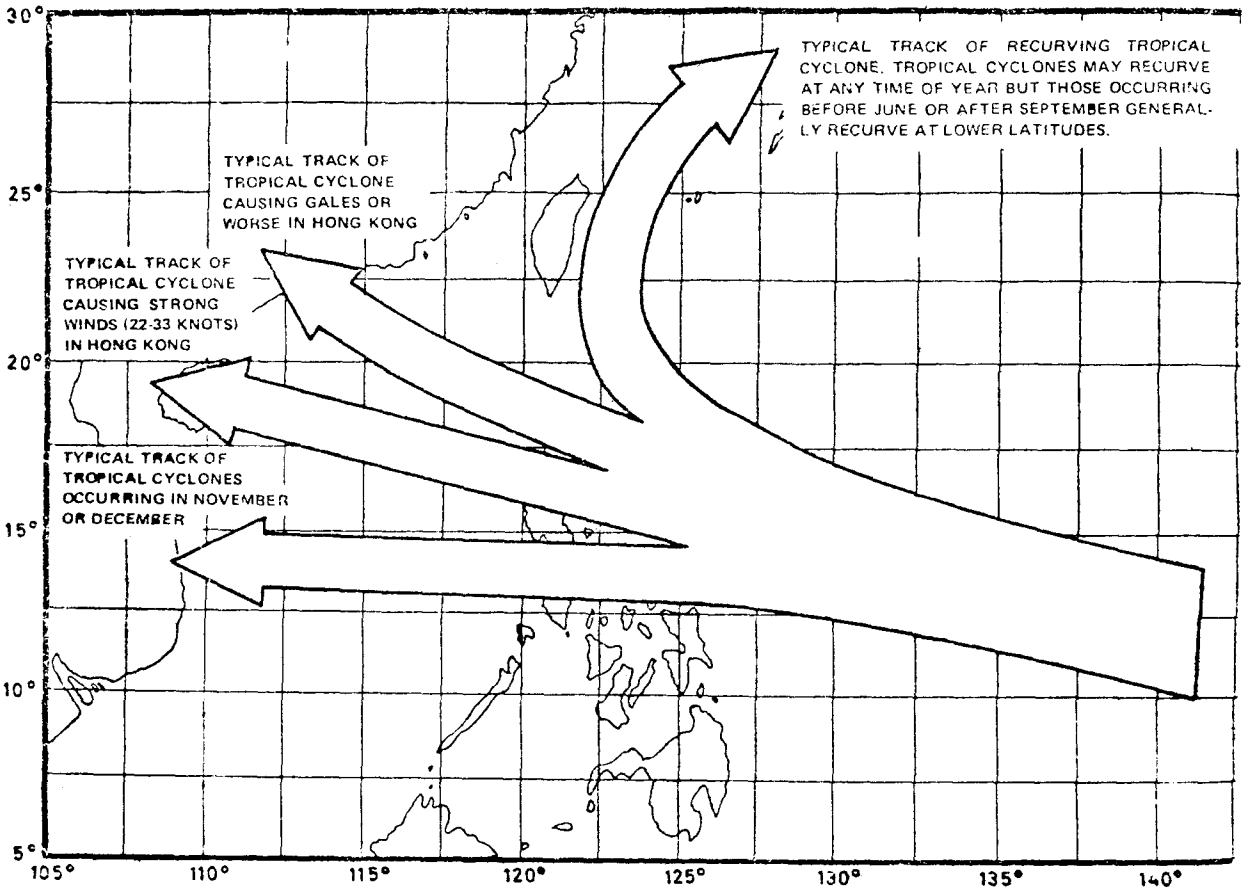

Figure 1. TYPICAL TRACKS OF TROPICAL CYCLONES

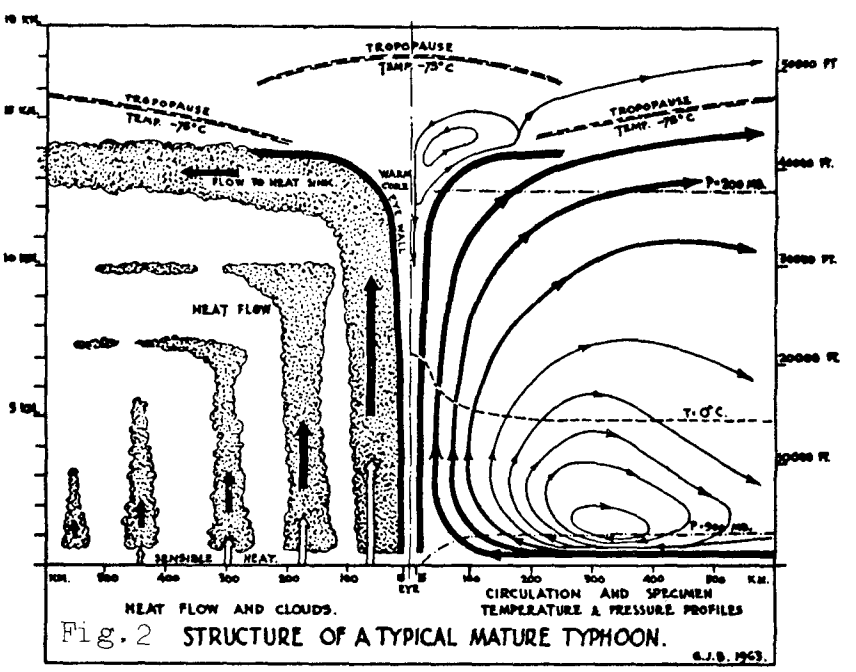

Fig. 2 STRUCTURE OF A TYPICAL MATURE TYPHOON.