

Some Notes on the Structure of
Hong Kong Typhoons

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Summary

A short spell of fine weather is almost always experienced in Hong Kong when a typhoon is approaching from the SE. It lasts until the centre of the storm is on the average about 300 miles away, and is attributed to divergence in the trade-wind stream which has overtaken the typhoon on its northern side.

If the dew-point in Hong Kong is several degrees below normal when a typhoon is approaching, the latter is likely to lose intensity as the drier air enters its circulation. This sometimes happens in autumn when the NE monsoon has set in along the China Coast.

Rainfall observations made during the passage of typhoons indicate that the heaviest precipitation occurs some distance outside the eye of the storm. This is confirmed by radar photographs, which show a ring of very heavy rainfall whose radius is greater than that of the eye. Rainfall after the passage of the centre tends to be heavier and more prolonged than during its approach.

The tropical storm of 23rd November, 1939, is described, as it showed several unusual features. It approached Hong Kong from WSW, presumably carried along by the upper westerly airstream which prevails over S. China in winter. The great majority of typhoons affecting Hong Kong occur earlier in the season and approach from SE. This was the only occasion on record on which the eye of a tropical cyclone passed over the Observatory; observations made within the eye are briefly described. A fresh surge of the NE monsoon reached Hong Kong just after the centre had passed, and the storm became extra-tropical in type.

1. *Introduction.* Regular weather observations have been maintained at the Royal Observatory, Hong Kong, for the past 70 years, and during that period there have been some 80 gales due to the passage of tropical cyclones at various distances from the city. The observations made on these occasions cannot be considered as representative of typhoons in their undisturbed state over the open ocean, for by time they are approaching Hong Kong they are already beginning to be influenced by the proximity of the coast. Moreover the readings of wind and rainfall at the Observatory are likely to be affected by the hilly nature of the surroundings. A study of the observations, however, reveals a number of interesting facts which throw some light on the structure of tropical cyclones.

2. *The fine spell in advance of a typhoon.* A short spell of fine sunny weather is almost always experienced in Hong Kong when an approaching typhoon is

entering the S. China Sea in the region of N. Luzon or the Luzon Strait. The sky does not usually begin to cloud over until the centre of the typhoon is on the average 300 miles away, though this distance varies widely according to the size of the approaching storm. Upper-air observations show that the trade-wind stream which overtakes a westward-moving storm on its northern side tends to diverge on reaching the area to the NW of the typhoon; this divergence and the resulting subsidence causes the fine spell observed in Hong Kong (Thompson, 1951). There is no corresponding fine spell after a typhoon has passed; the subsidence appears to be confined to the area in which there is marked divergence in the trade-winds, and there is no evidence of general subsidence around the periphery of the storm as indicated in the model suggested by Bergeron (1954). Although some of the air which has ascended in the core of the storm may be carried forward in the accelerated trades aloft and may subsequently descend in the divergent area, it seems hardly likely that this mechanism can dispose of all the ascending air. It must therefore be assumed that most of the air flowing out aloft from the storm does not immediately descend; according to Riehl (1954) it mixes with the surrounding air masses at high levels and is carried away by them.

3. *Effect of dry air at the surface.* If the dew point in Hong Kong is several degrees below the normal for the month at a time when a typhoon is approaching from south-eastward, the latter generally begins to lose intensity. This sometimes happens in autumn after the NE monsoon has set in along the China Coast; the current of comparatively cool dry air entering the typhoon circulation at the surface cuts off part of the supply of moisture on which the typhoon depends for its energy. A striking example occurred in October, 1950. On the night of the 4th to 5th the dew point in Hong Kong was 62°F or 7° below the normal for that season. A fully-developed typhoon was then centred only about 170 miles to the south-east. During the next 24 hours the typhoon rapidly degenerated to a tropical storm; pressure began to rise in Hong Kong while it was still approaching, and when the centre passed 70 miles to the SSW on the afternoon of the 5th the wind at the Observatory only just reached gale force for one hour. This however was an extreme case; the decrease in intensity due to the intrusion of dry air is usually much slower, and it is not safe to forecast a rapid filling up of the typhoon on these occasions.

4. *Rainfall distribution.* Radar photographs of tropical hurricanes show belts of precipitation in the gale area, spiralling in towards the centre. The most intense rainfall is in a more or less circular ring around the centre but at some distance from it. Radarscopes of typhoon "Susan", which passed some 40 miles to the south of Hong Kong on 18th September, 1953, indicated that the ring of heaviest precipitation was about 20 miles in radius. An inner ring about 10 miles in radius was faintly discernible; this probably coincided with the wall of the eye. This

rainfall pattern conforms with the model suggested by Bergeron (1954), in which the heaviest rainfall is located some distance outside the wall of the eye.

Rainfall measurements in Hong Kong tell the same story, though too much reliance should not be placed on the readings of raingauges in high winds. There is often a distinct diminution of rainfall for a short while as a typhoon centre is passing Hong Kong, even though no part of the eye passes over the station. This effect has been noticed on about half the total number of occasions on which a typhoon centre passed at distances ranging from 10 to 80 miles from the Observatory, which seems to indicate that the ring of very heavy rainfall may sometimes be of considerable radius. Rainfall after the passage of the centre tends to be heavier and more prolonged than during its approach, since the northerly winds in advance of a typhoon have been blowing off the land, while the southerly winds in its rear bring moisture-laden air from the sea.

5. *The tropical storm of 23rd November, 1939.* This storm was no longer of typhoon intensity when it passed Hong Kong, but it is of special interest on account of its very unusual track, and because for the only time on record the eye of the storm passed over the Observatory. The great majority of typhoons which affect Hong Kong approach from the SE quadrant; this one recurved over the S. China Sea and approached from WSW, presumably carried along by the upper westerly airstream which prevails throughout the winter at heights above 10,000 feet or so over the S. China coast, and was blowing at that time. It is noteworthy that no typhoon has been known to approach Hong Kong from an easterly or south-easterly direction when the upper westerly wind was blowing aloft.

As the centre passed over Hong Kong the south-easterly gale dropped abruptly to a light breeze, and the rain ceased entirely for some minutes. The sky did not clear in the eye of the storm, but the clouds thinned appreciably. The surface temperature in the eye was about 3°F higher than in the gale area, but the relative humidity remained constant at 95%. The lull lasted for 15 minutes, after which a strong wind set in from NW—a complete reversal in direction. Observations of the lull in various parts of the Colony indicated that the eye was oval in shape, measuring about 4 miles from E to W and 10 miles from north to south.

A fresh surge of the NE monsoon reached Hong Kong immediately after the passage of the centre, affording a unique opportunity of observing the transformation of a tropical storm into an extra-tropical one as the cold front penetrated the central region. Temperature fell more than 10°F in a few hours, and the arrival of the cool dry air resulted in a surprisingly rapid improvement in the weather after the centre had passed; rain continued for less than an hour and the low clouds soon began to break. The storm continued to lose intensity as it

moved away eastward from Hong Kong, and it finally filled up to the south of Okinawa two days later.

References

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Riehl, H., 1954: "Tropical Meteorology", p. 321.
Thompson, B. W. T., 1951: *Quart. Journ. Roy. Met. Soc.*, **77**, p. 282.

Discussions

J. NAMIAS: I was pleased to hear Mr. Heywood bring out the importance of dry air entering the storm as an important factor leading to filling. This fact was used to advantage during the decade of the 1930's when isentropic analyses brought into sharp focus the dry tongues of air which were occasionally evicted from the upper temperate westerlies over the North American Continent into hurricanes, leading to dissipation. The method of isentropic analysis is ideally suited to utilizing this concept in typhoon prediction.

R. D. FLETCHER: In the US, hydrometeorologists recognize two types of "hurricane" rainfall. The first is the very intense, short-duration rainfall covering a few 100's of square miles far in advance (several hundred miles) of the hurricane center. This rain seems to be associated with the forward edge of a sharp high-pressure ridge preceding the storm. In a very few hours, nearly 20" of rain have been observed in this synoptic type.

The other type is the fairly continuous, long-duration, large-area rainfall which accompanies and follows passage of many of the hurricanes. This type produces large volumes of water. For instance, an average of 15" to 20" over thousands of square miles can fall in a period of many hours to a few days.

C. E. DEPPERMAN: In the rear of trade wind--SW monsoon typhoons, if the storm continues into the continent the weather clears rapidly and descending air is manifested by very large cirrus virgae. If typhoons recurve to our north, the squally stormy weather may continue from three to five days as long as we continue to get the SW monsoon.

In front of typhoon, there may or may not be descending air.