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A synoptic study of Rameswaram Cyclone of December 1964 and the storm wave caused by it

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ABSTRACT. The Rameswaram Cyclone of December 1964 was one of the severest storms that occurred in the Indian Seas and probably the most severe storm which affected Ceylon and the extreme south of the Indian peninsula. The storm was unique in many respects. The latitudes at which the initial disturbance was formed, at which it concentrated into a cyclonic storm and at which it further intensified into a severe storm — are probably the lowest on record. Winds estimated in the core of the storm when it was over Ceylon are the highest ever experienced there. It caused unprecedented floods in Ceylon. It caused tidal waves over Mannar and Rameswaram islands which, according to the recorded history of cyclones, are rarely experienced in these areas.

The three-dimensional structure of the storm during its different phases and the upper air conditions which seem to have favoured its intensification have been discussed in the paper. The peculiarities of its surface structure, which seemed to have had a direct bearing on the rainfall distribution and the occurrence of storm waves have been also pointed out.

1. Introduction

The Rameswaram Cyclone of December 1964 can be considered to be one of the most severe cyclones that occurred in the Indian seas. It caused unprecedented damage in the northern parts of Ceylon and southern parts of Madras State. Storm waves accompanying the cyclone invaded the small islands of Mannar (Ceylon) and Rameswaram (India). More than a thousand people lost their lives and damage to property ran into crores of rupees.

The storm was unique in many respects. We have collected all the available data pertaining to the storm from various sources, and have made a detailed study of its three-dimensional structure. The salient points which emerged from this study are discussed in this paper.

2. Life history of the storm

A depression formed in the extreme southeast Bay of Bengal on 16 December 1964 with its centre near 4·5°N, 93·0°E. It remained stationary near that position during the next three days, causing squally weather and rough seas over the area. A composite chart of all the ships' observations in the vicinity of the depression from 17 to 19 December together with the mean position of the centre of the depression is given in Fig. 1. Only the pressure and wind reported by the ships have been plotted in the diagram to avoid congestion. To have an idea of the intensity of the disturbance and its stationary nature, isobars have been drawn for even values of mean atmospheric pressure in the area. The date and time of observation (in GMT) of each ship's report has been given near the position of each ship.

The depression intensified into a cyclonic storm during the night of 19th and lay with its centre near 5·5°N, 90·0°E on the morning of 20th. It intensified further into a severe cyclonic storm by that evening. Subsequently it moved westnorthwestwards and lay with its centre near 6·5°N, 88·0°E on the morning of 21st, and near 7·5°N, 85·0°E on the morning of 22nd. Its movement was accelerated on the 22nd. It moved northwest at an estimated speed of about 18 knots and was centred near 9·0°N, 82·0°E at 1200 GMT of 22nd. Its further movement was almost westwards across north Ceylon. The storm centre seemed to have passed during the night right across Vovuniya town in the central part of north Ceylon. The storm lay in the Palk Strait with its centre near 9·3°N, 79·5°E (near Dhanushkodi) at 0000 GMT of 23rd. Then it moved northwestwards and struck the south Madras coast near 9·5°N at about mid-day of 23rd. It weakened thereafter and moved further westwards. It lay as a cyclonic storm with its centre near Madurai on the evening of 23rd and as a low pressure area over Malabar the next morning. The track of the storm is shown in Fig. 2.

3. Climatological comparison

The formation of a depression at as low a latitude as 4·5°N happens extremely rarely over the Indian seas. The previous records regarding the formation of depressions in the last 88 years (India met. Dep. 1964) are as follows —

27 December	1921	5·0°N, 86°E
12 January	1925	4·0°N, 81°E
9 December	1931	5·3°N, 81°E
29 February	1944	4·5°N, 85°E
16 December	1954	4·5°N, 86°E

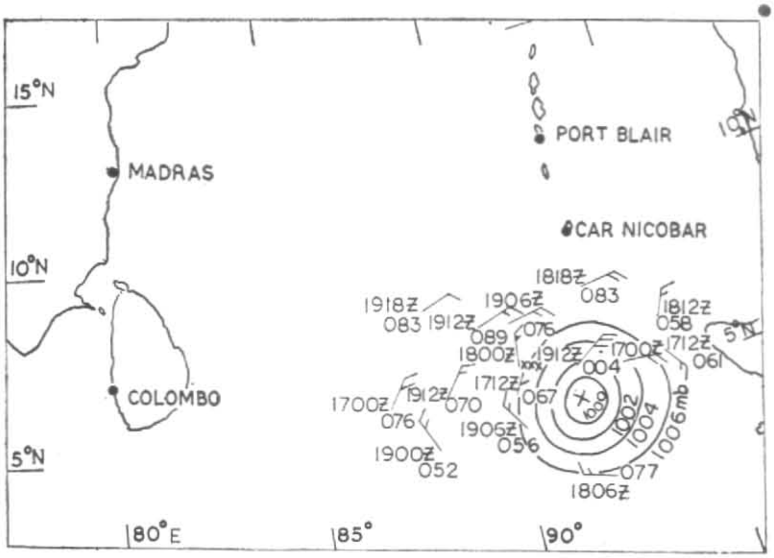

Fig. 1. Composite chart of ships' observations in the vicinity of the depression from 00 GMT of 17th to 18 GMT of 19th

The mean position of the centre of the depression is marked by × and the mean isobaric configuration is also shown

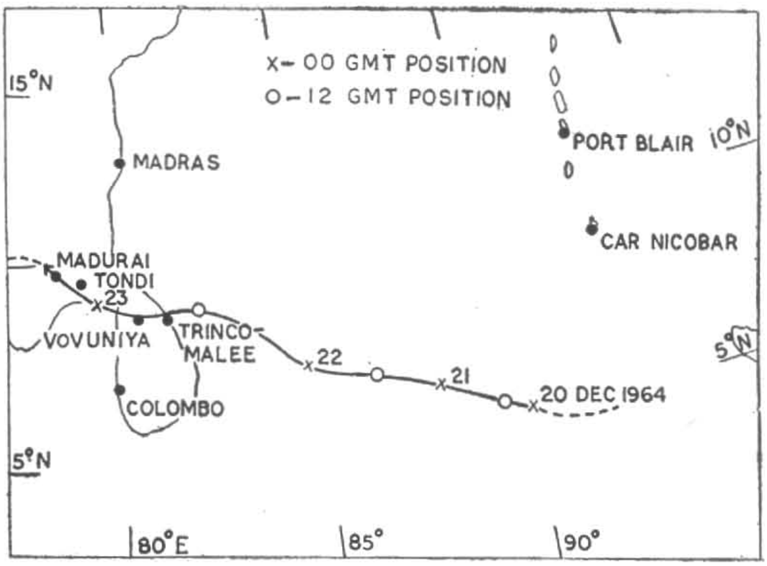

Fig. 2. The track of the storm

(For locations of places mentioned in the text, see Fig. 8 also)

It is to be noted that none of the above five depressions intensified into cyclonic storms.

The intensification of the depression into a cyclonic storm at as low a latitude as 5·5°N is a record. The previous known cases of formation of cyclonic storms at very low latitudes are—

17 December	1912	5·5°N, 82°E
14 January	1918	6·5°N, 86°E
5 May	1930	6·0°N, 83°E

The Rameswaram storm became severe at as low a latitude as 6·5°N. It is also perhaps the only severe cyclonic storm to have moved across the Palk Strait during the last eighty years for which storm tracks are available, except for the Adiramapatnam storm of November 1955 which moved westwards across the northern fringes of the Palk Strait.

4. Surface structure of the cyclone

The areal extent of the storm was very small throughout its life span. During the depression stage, the closed isobaric field extended to about 3° of latitude from the centre. As it concentrated into a cyclonic storm, the field of gales was confined to about 100–150 km from the centre. During the severe storm stage the inner ring of hurricane winds was only about 40 km in width.

Though small in extent, the storm seemed to have surpassed all earlier storms in its fury and destruction caused. It was at its maximum fury when it struck the east coast of Ceylon just to the north of Trincomalee. At 0900 GMT of the 22nd, the winds were moderate being northwesterly 20 knots. By 1200 GMT gales and heavy rain commenced, in another two hours Trincomalee was ravaged by hurricane winds. Estimates of wind speed at Trincomalee range between 120–150 knots, There is no report of a calm centre from here. Apparently the eye passed slightly to the north of the station. Moving westward, the storm struck Vovuniya town. Estimates of wind speed here range between 150 to 175 knots, which are the highest reported from any place in association with this storm. They are probably the highest ever experienced in Ceylon.

The storm weakened a little by the time it reached Palk Strait. Mannar had winds of about 15 knots at 1500 GMT and 25 knots at 1800 GMT. By 2000 GMT, this small town was devastated by winds which exceeded 90 knots (the limit of the Dines P.T. Anemogram chart there was 100 mph). Estimates of the wind speed here range between 100 and 120 knots. The storm continued to weaken during the 23rd as shown by the estimates and records of winds — 80 to 90 knots over Rameswaram area, 60 to 70 knots at the east coast of India (Tondi) and 45 knots at Madurai.

Pressure data from the central areas of the storm are scanty. Trincomalee recorded 992 mb at 1200 GMT on 22nd and 990 mb at 1500 GMT. The storm passed the longitude of the station in between these two synoptic hours. Mannar which was more directly in the path of the storm recorded 978 mb at 2100 GMT of 22nd. The bar fell by 22 mb between 1800 and 2100 GMT. It rose by 25 mb between 2100 and 2400 GMT (0000 GMT of 23rd). The lowest pressure of 978 mb recorded at Mannar probably represents the central pressure of the storm when it reached the west coast of Ceylon. The central pressure when it was near the east coast of Ceylon might have been even lower.

By the time the storm crossed the east coast and eached Madurai, the central pressure had risen onsiderably and at 1200 GMT of 23rd it was round 996 mb.

A rather well marked feature of this storm was the structure of the outer isobaric field. This shows a north-south trough in which one or two weak vortices were apparently imbedded to the south of the storm. Sections of the synoptic charts of 1200 and 1800 GMT of 22 December 1964 are shown in Figs. 3 and 4 respectively. These charts indicate the weaker cyclonic systems to the south of the storm with marked north-south orientation of the isobars in both the forward and rear sectors of the storm. This feature of the isobaric system seemed to have an effect on the rainfall distribution and the storm-wave phenomena to be discussed later. The time cross-section of winds over Colombo during the period 21 to 23 December 1964 is given in Fig. 5. The 'Calm' at 0000 GMT of the 23rd at the surface, the weakening of winds in the lower levels, when the storm was passing nearest to the station indicate the presence of weaker vortex to the south of the main storm area.

As usual with a storm of this intensity, there was a well developed 'eye'. The radius of the 'eye' may be estimated to be between 6 and 7 km. It passed over Rameswaram between 0130 and 0230 GMT and over Pamban between 0230 and 0330 GMT of the 23rd.

It will be observed from Figs. 3 and 4 that on the surface there is no significant contrast of temperature and dew point in the vicinity of the cyclone. This conforms to the now accepted notion that no low-level frontal structure can be generally invoked to account for the intensity of low-latitude cyclones.

5. Upper air conditions

As is usual with disturbances in oceanic areas, the upper air data are too meagre to arrive at definite conclusions. The upper air stations nearest to the storm during its formative stages are Port Blair to the north and Songkhla to the east and both of them were about 800 km away. A few aircraft reports are available for the period and they have thrown some light on the vertical structure of the storm.

The sub-tropical high pressure belt had its axis near latitude 15°N over the Bay of Bengal at 700 mb and near latitude 13°N at 500 mb during the third week of December. The depression formed in the equatorial easterlies to the south of this belt, probably very near the axis of the equatorial trough. On the 16th an anticyclonic cell was situated to the northwest of the disturbance in the middle tropospheric levels. Aircraft reports indicated that the cyclonic circulation extended upto 700 mb. These conditions remained more or less unchanged till the 18th, during which period the depression did not intensify and remained nearly stationary.

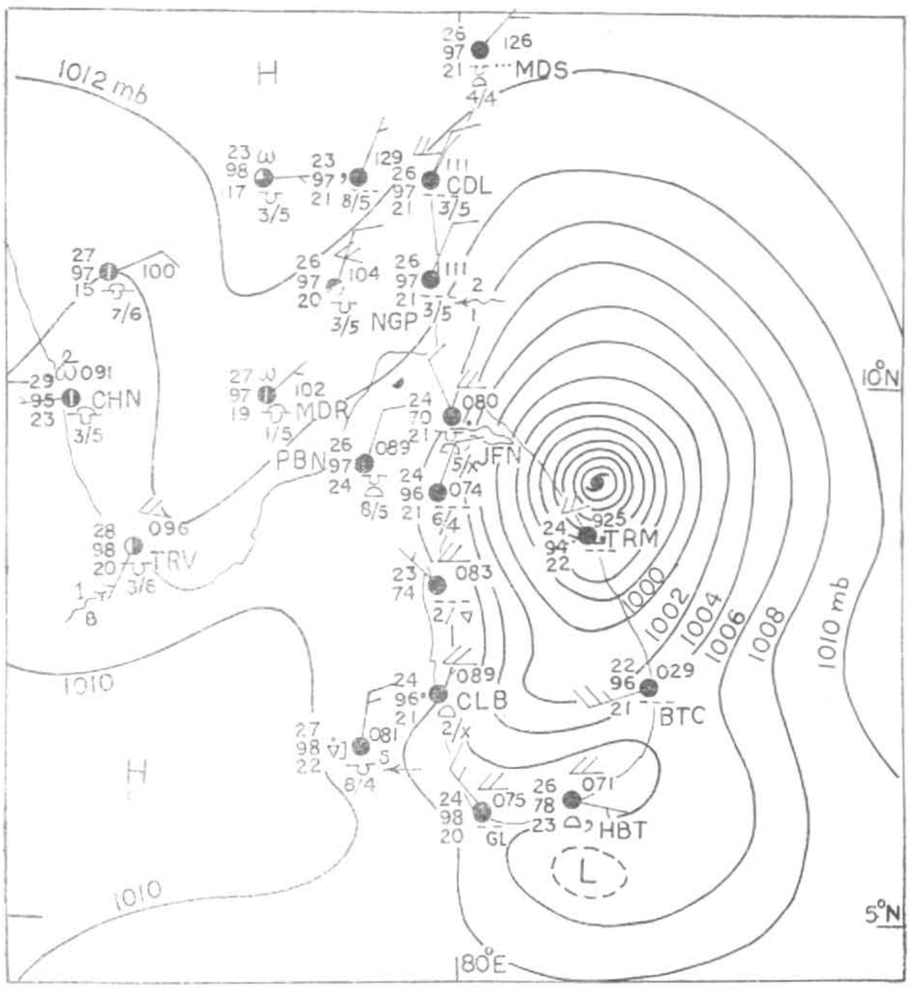

Fig. 3. Section of 1200 GMT chart of 22 December 1964

(Central pressure of storm probably 975 mb. Trincomalee wind data absent)

Major changes in the middle tropospheric circulation were observed in the region on the 19th. The morning upper air charts and the available aircraft reports indicated a well-marked wave in the upper easterlies with its axis at 300 mb 2 to 3 degrees to the east of the surface centre of the depression and roughly along longitude 93°E. The upper winds over Port Blair between 14 to 23 December 1964 are shown in Fig. 6. The winds over Port Blair which were having a marked northerly trend in the middle tropospheric levels till the 19th veered rapidly and became E/ESE thereafter. The aircraft data also suggested that the cyclonic circulation on this day may have extended to about 6 km a.s.l.

The upper winds over Ceylon and south India on 22nd indicate that the cyclonic circulation of the storm extended up to 400 mb. There was no evidence aloft of the existence of any cyclonic vortex. This may be either due to the absence of such a circulation or due to the areal extent of the circulation tapering off rapidly and becoming so small that it could not be detected. The latter was possibly the case, judging from the known normal structure of tropical cyclones of small extent. Colombo winds at 1200 GMT of 22nd definitely indicate a flow away from the storm centre at 10·5 km and above, a feature which is in conformity with the usually accepted pattern of flow at these levels. The movement of a trough in the easterlies at the 300 and 200 mb levels over Colombo between 22nd and 23rd is also shown by the time-section of Colombo winds (Fig. 5).

The significant upper air features shown by the available data can be briefly summarised as follows —

The low-level disturbance formed in the south-east Bay of Bengal on the 16th at the equatorial trough, probably under the influence of a weak low pressure system which moved in from the east.

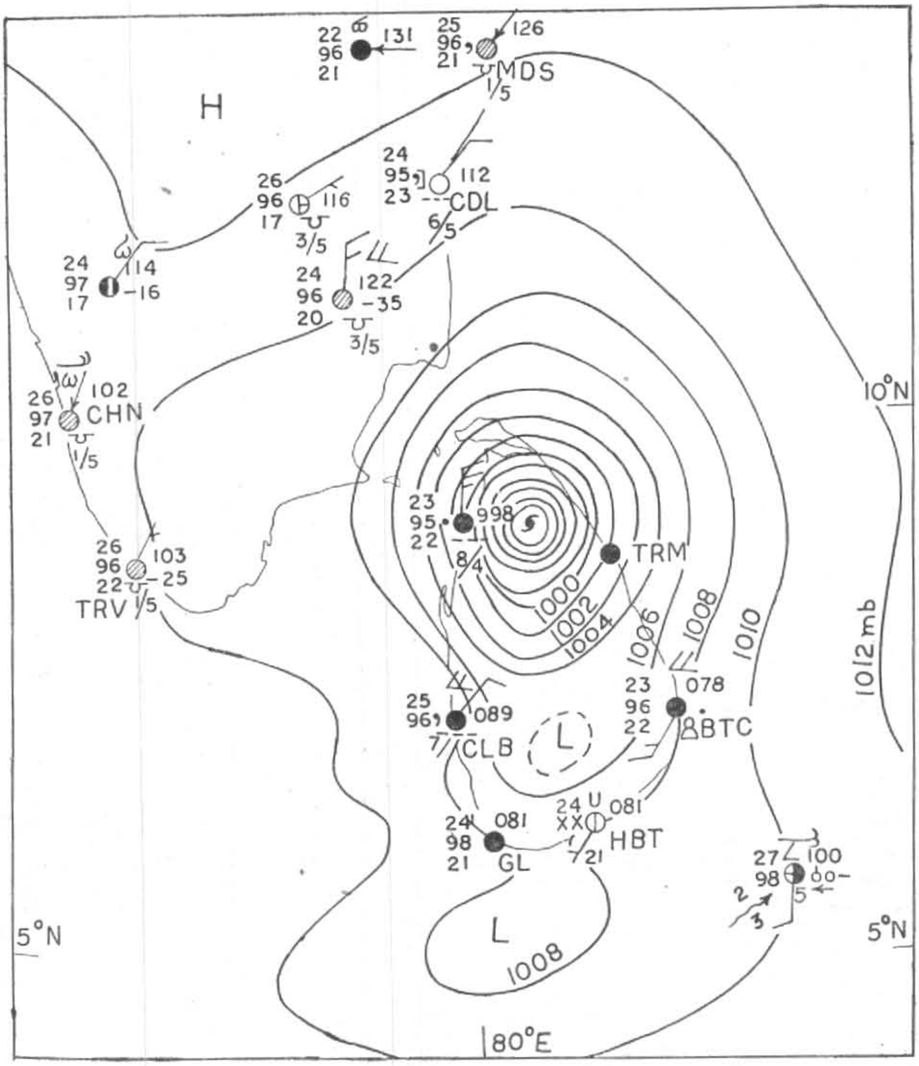

Fig. 4. Section of 1800 GMT chart of 22 December 1964

(The storm had moved by about 100 nautical miles since 1200 GMT)

The system intensified under the influence of favourable factors in the middle tropospheric circulation over the area on the 19th. The system came under the influence of an upper divergent field at 300 mb and aloft in the form of a westward-moving trough in the easterlies and the cyclonic circulation associated with the storm extended to 400 mb on this day. As the storm entered the land areas of Ceylon and India, its movement was retarded and the upper trough overtook the low level system. This factor and the greater inflow, due to friction as the storm travelled over land, seem to have resulted in the rapid weakening of the storm on the 23rd.

6. Rainfall and Floods

Torrential rains were caused by the storm along its track. Vovuniya received 25 cm of rain on the 23rd and Madurai recorded 23 cm on 24th. The rains caused unprecedented floods in north Ceylon. Roads at some places here were reported to be 30 ft (10 m) under water after the passage of the storm. The rains in Madurai district resulted in extensive damage to a number of irrigation canals and tanks leading to widespread flooding.

The cumulative rainfall associated with this storm from 21 to 25 December over Ceylon and south peninsular India is shown in Fig. 7. Data from the storm-ravaged areas of north Ceylon are meagre and so isohyetals have been drawn by interpolation and are shown by broken lines in Fig. 7.

The chief features of the rainfall distribution shown in Fig. 7 are—

(1) A belt of very heavy rain along the track of the storm;

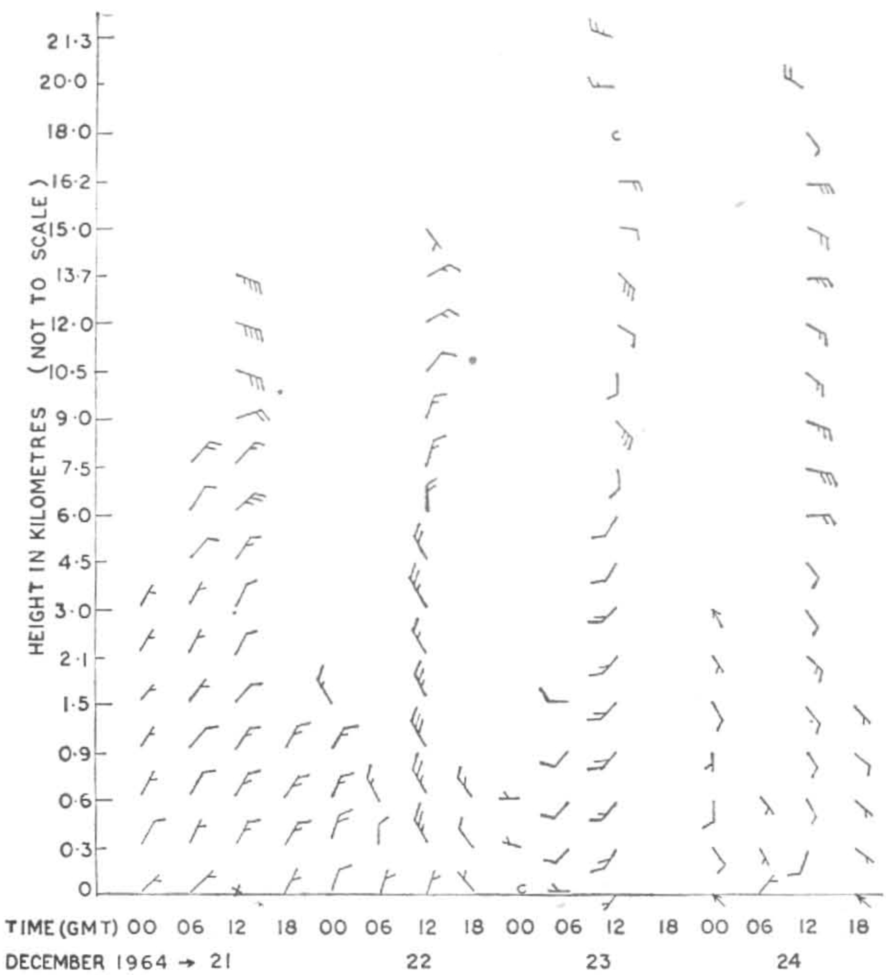

Fig. 5. Winds over Colombo

(2) A secondary area of very heavy rain along the coastal strip from Point Calimere to about 100 miles to the north; and

(3) A sharp decrease of rainfall to the south of the storm track.

While the belt of torrential rains along the track is a fairly common occurrence, the reason for the second area of heavy rainfall is not so obvious. Two possible favourable conditions seem to have caused the heavy rainfall in this second area. Firstly, this part of the coast came under the influence of the storm when it was in its full fury. The daily rainfall data show that a good percentage of the rain in this area occurred before 0830 IST on 23rd. Secondly, the isobaric north-south trough mentioned earlier did not break up into secondary vortices to the north of the storm as it did to the south. The convergence associated with this trough apparently contributed to the occurrence of the very heavy rainfall in this area.

On the other hand, the existence of a secondary vortex in the lower layers to the south of the main storm field seems to have had an inhibiting effect on the convergence in the zone between the two systems resulting in a sharp decrease of rainfall to the south of the storm track.

Apart from these broad aspects, another noteworthy feature of the rainfall distribution was its large variability in space. Places even a few miles apart along the track of the storm received widely different amounts of rainfall. Madurai town received 25 cm of rain in association with this storm while Madurai Airport, which is only 12 km away received only 12 cm of rain. A similar uneven distribution was also noticed in the second area of heavy rain near the coast. Some places received rainfall of 10–15 cm while adjacent places recorded only moderate rains of 3 to 4 cm. Hence, the isohyetals shown in Fig. 7 indicate only the broader features of rainfall distribution.

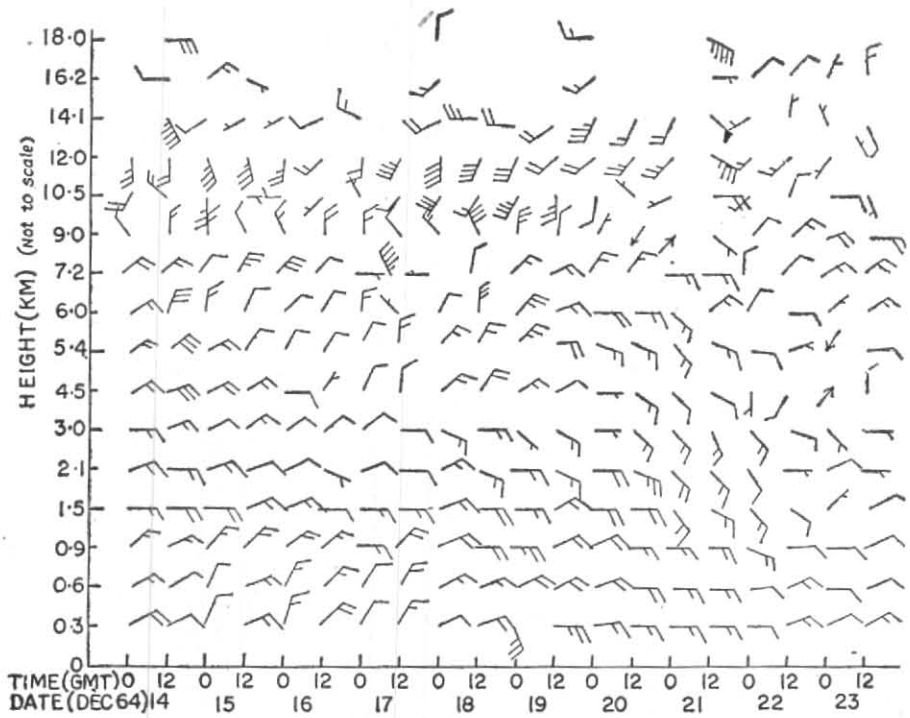

Fig. 6. Upper winds over Port Blair

7. Storm surges

The storm caused large tidal waves over the islands of Mannar (Ceylon) and Rameswaram (India), which stretch east to west between the Palk Strait and the Gulf of Mannar. The storm waves caused great devastation and loss of life at both the places.

Moderate northeast monsoon winds of 15 to 20 knots were prevailing over the straits and the adjoining Bay of Bengal on the 21st and 22nd. Thus waves and swells with long 'fetches' were already present in the area before the storm actually struck. The winds started freshening up rapidly as the storm advanced. Even though the diameter of the inner storm area was small, the curvature of the isobars in the outer storm field was small on account of the north-south trough mentioned earlier. Thus the winds over the entire length of the straits strengthened without any appreciable change in direction, resulting in rapid piling up of waters along the northern coasts of the islands.

Hurricane winds commenced at each place 3 to 4 hours in advance of the arrival of the storm centre. With the onset of these hurricane winds, storm waves over-ran parts of these islands, sweeping away everything before them. According to available data, the waves rose 5 to 6 metres a.s.l. At exposed places like Dhanushkodi the waters overflowed right across the island into the Gulf of Mannar to the south. The waves swept away an

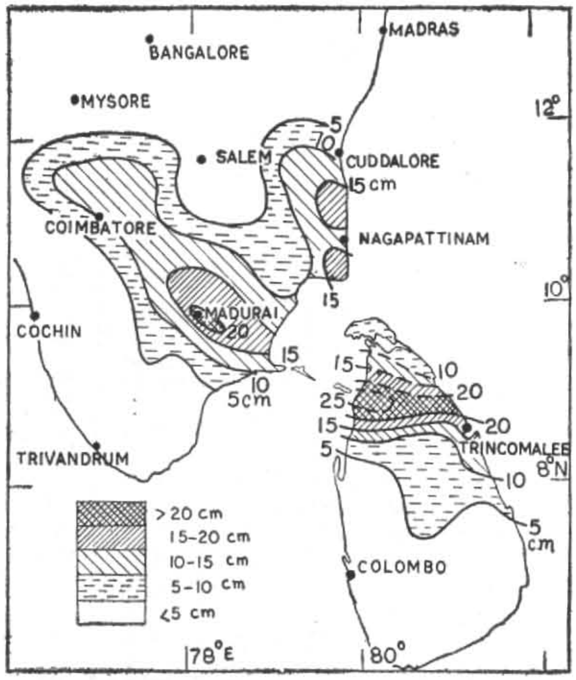

Fig. 7. Rainfall associated with the cyclonic storm — cumulative rainfall from 21 to 25 December 1964 in Ceylon and in south Madras State is shown

entire passenger train with 120 persons on board off the track and washed away hundreds of the islanders.

Similar fate seems to have been met with by several smaller villages along the northern coasts

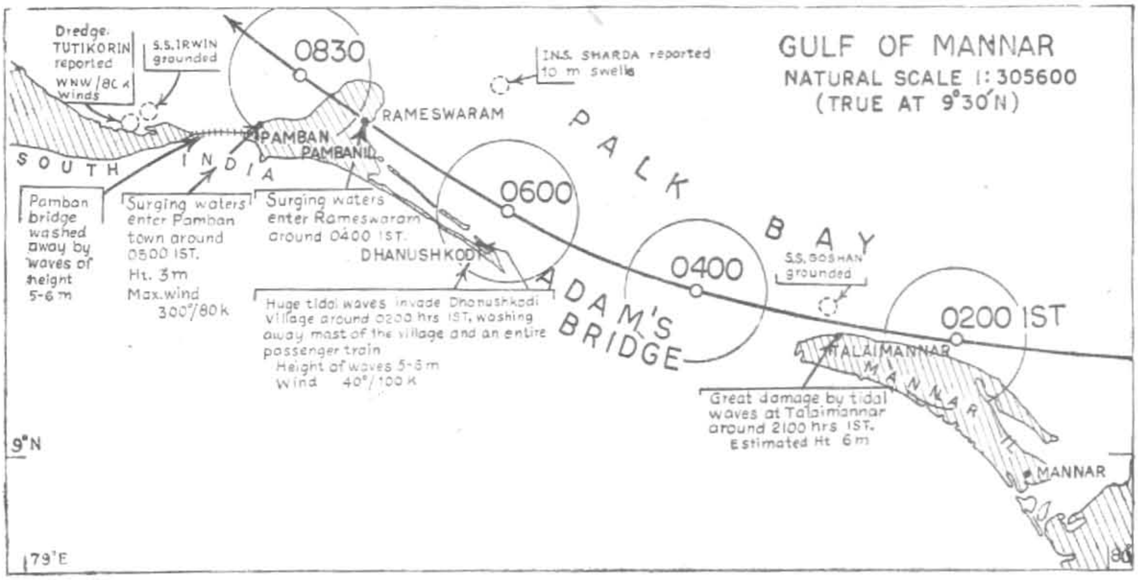

Fig. 8. Detailed map of Rameswaram — Mannar area

The track of the storm is shown by the thick line. The probable positions of the Calm centre are shown by circle. Details of the storm wave, the destruction caused by them, the time of their occurrence and the wind speed at the time of storm surges is given at each place. Approx. positions of the ships, interesting observation recorded by them are also given

of the island. At the western end of the island, the famous Pamban bridge, which links the island with the mainland was washed away by storm waves. Waves and swells reaching to 6 metres a.s.l. swept away the bridge which is generally 4 to 5 metres a.s.l. Several days after the storm had passed and the sea had receded, parts of the island were still submerged in sea water. Drinking water sources were badly damaged or completely destroyed.

Storm surges of a lesser height occurred along the eastern shore of the Palk Strait to the right of the storm-track causing inundation of the coastal areas, resulting in the ruin of rich agricultural lands, irrigation tanks and fresh water reservoirs and wells. About nine thousand acres of land were filled with silt, sand or saline waters making them unfit for cultivation.

The relationship between the surface winds and the heights of storm surges is shown in an earlier paper by the present authors (see Ref.). A diagram from this paper which gives the details of the storm surges which affected the different parts of these islands is reproduced in Fig. 8.

8. Conclusions

The concentration of the depression into a cyclonic storm seems to have taken place with marked changes in the middle tropospheric circulation near the disturbed area. The intensification was facilitated by a wave in the upper easterlies. The upper air cyclonic circulation associated with the storm extended up to 400-mb level during its severe stage and could not be detected further aloft.

The peculiarities of the surface isobaric field had an additional effect on the rainfall distribution and storm wave phenomena which occurred in association with this storm.

9. Acknowledgements

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