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The severe cyclonic storm of 11-12 June 1964 in the Arabian Sea and some of its surface characteristics

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ABSTRACT. A severe cyclonic storm which developed in the east central Arabian Sea in the second week of June 1964, moved northwards and struck the Kathiawar coast causing serious havoc. A brief account of this storm together with the relevant synoptic features are given in the paper. The study reveals some of the noteworthy surface characteristics of the storm in respect of surface pressure, wind field, speed of movement and surface temperature which are discussed in the paper.

1. Introduction

In many years the onset of the southwest monsoon over Kerala occurs in association with the formation of a cyclonic disturbance in the southeast Arabian Sea. Such systems which generally move in a northerly direction cause the further advance of the monsoon northwards along the west coast. Some of these disturbances develop into depressions; those which reach storm intensity are rare. The onset of the monsoon over the west coast of India in June 1964 occurred in association with such a disturbance which intensified into a severe cyclonic storm and struck the Kathiawar coast. A brief account of some of the noteworthy features associated with this storm are given in this note.

2. Brief account of the storm

2.1. A trough of low pressure developed over the east central Arabian Sea off the Kanara coast on 6 June 1964. Moving northwards it intensified and concentrated into a depression with centre near Lat. 17°N and Long. 71°E by the morning of 9th. Thereafter, it moved northnorthwestwards and intensified into a cyclonic storm of small extent by the next morning and into a severe cyclonic storm by the morning of 11th when it lay about 90 km west of Veraval. It began to recurve northeastwards from the morning of 12th and crossed coast just west of Naliya during the late forenoon on 12th. It rapidly weakened into a depression by 13th and finally broke up over the Western Himalayas by 14th. The track of the storm is shown in Fig. 1.

2.2. According to press reports, the cyclone whipped up high intensity tidal waves, damaging many houses on the sea coast. Six steamers in Bedi port near Jamnagar were drifted into the sea, many country crafts sank and a barge loaded with bauxite capsized in the stormy sea. Twentyseven persons lost their lives due to the cyclone. According to the information collected by the Meteorological Office, Bombay, two to three furlongs of Asmavathi road together with the 25-ft wide basement foundation of the 20-ft high protection wall along the sea coast was completely washed away at Porbandar. Tidal waves were reported to have risen higher than at any time in the past at most of the ports. The storm tides were about 6-ft high at Kandla, 4-ft high at Okha and 2-3 ft high at Navlakhi on 12th.

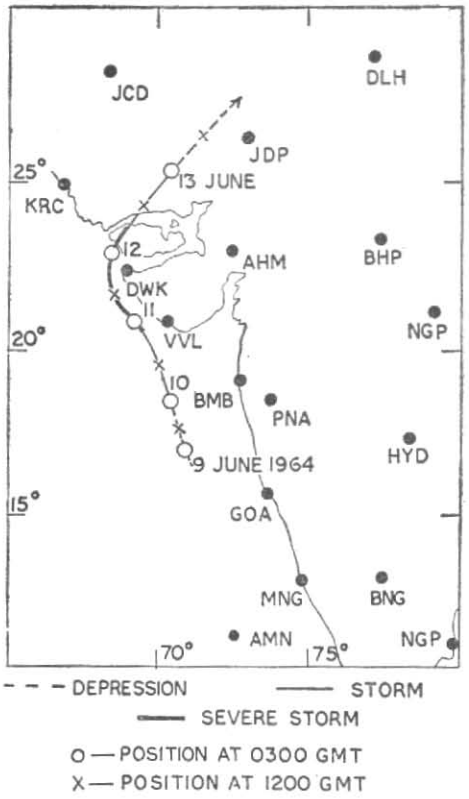

Fig. 1. Track of the severe cyclonic storm

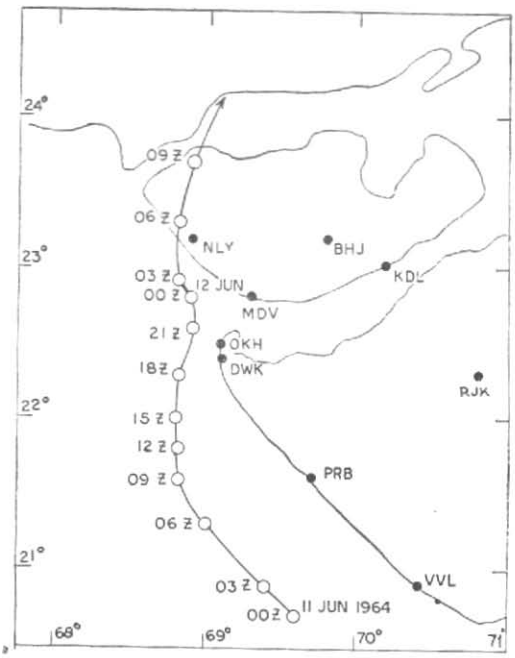

Fig. 2. Detailed track showing positions of the storm centre at 3-hourly intervals

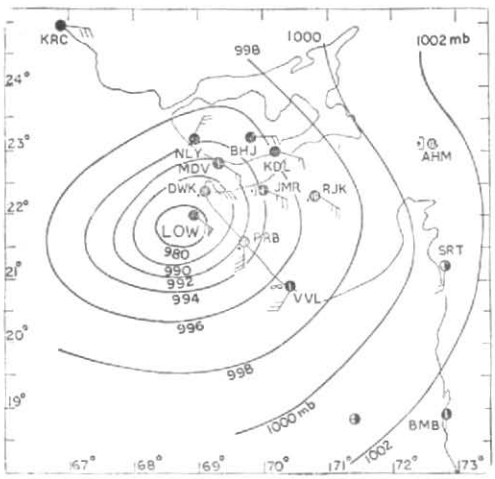

Fig. 3. Isobaric chart at 1200 GMT on 11 June 1964

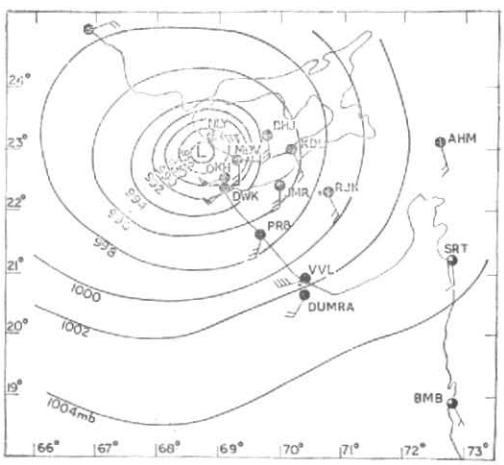

Fig. 4. Isobaric chart at 0300 GMT on 12 June 1964

TABLE 1

Lowest surface pressure and highest wind recorded at coastal observatories

S. No.	Station	Date (June 1964)	Time (GMT)	Distance of storm centre from station (km)	Lowest pressure (mb)	Pressure defect (mb)	Maximum wind (deg./kt)
1	Veraval	11	0000	90	993·7	7·5	160/45
2	Porbandar	11	1100	90	991·5	9·5	160/40
3	Dwarka	11	1400	25	983·0	18·0	130/57 (at 17 Z)
4	Okha	11	2000	25	984·0	17·5	
5	Naliya	12	0400	10	969·5	32·5	090/73 (at 03 Z)
6	M.V. *Dumra*	11	1030		978·6	22·0	130/60

3. Synoptic features

3.1. In connection with this storm the hourly observations of Veraval, Porbandar, Dwarka and Naliya for 11 and 12 June 1964, were requisitioned by the Meteorological Office, Bombay. The ship, M. V. *Dumra*, plying towards Bombay, passed very near the centre of the cyclonic storm on 11th evening and provided hourly observations. Utilising these and other available surface data, synoptic charts were constructed at 3-hourly intervals from 00 GMT of 11th to 12 GMT of 12th. The track of the disturbance relating to the severe storm stage determined from the 3-hourly charts is shown in Fig. 2. The severe cyclonic storm of small extent was intensifying and had developed a core of hurricane winds by 03 GMT on 12th. The surface isobaric charts for 12 GMT on 11th and 03 GMT on on 12th, are given in Figs. 3 and 4 respectively. The hourly variations of pressure and wind at Veraval, Porbandar, Dwarka, Okha and Naliya and also as recorded by the ship M. V. *Dumra* are shown in Figs. 5 and 6 respectively. As the ship was moving in a direction almost opposite to that of the storm, the surface observations recorded by the ship at hourly intervals have been very useful for determining the centre of the storm and its intensity.

3·2. The coverage of data in the eastern sector of the storm field was quite good to have a satisfactory analysis. As the disturbance was a severe cyclonic storm, a nearly symmetrical pattern has been assumed in the inner field. It will be seen from Fig. 5 that the lowest pressure recorded at the stations from Veraval to Naliya showed a clear time sequence, which has also been taken into account in fixing the position of the storm centre at the various synoptic hours.

4. Discussion

4·1. Table 1 gives some of the significant surface pressure and wind details.

At 00 GMT on 11th the centre of the storm was about 90 km west of Veraval. As the storm was moving almost due north from 09Z of 11th and as the coastline was running

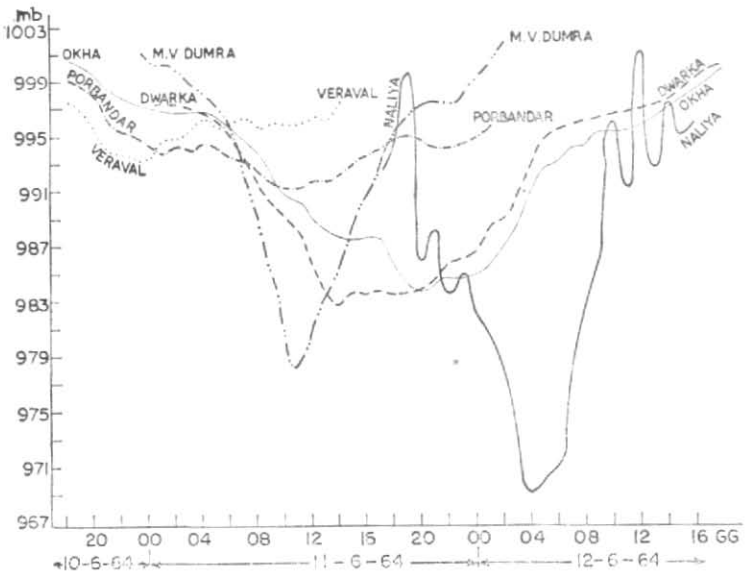

Fig. 5. Hourly variation of pressure at the coastal stations of Veraval, Porbandar, Dwarka, Okha and Naliya and the ship M.V. Dumra

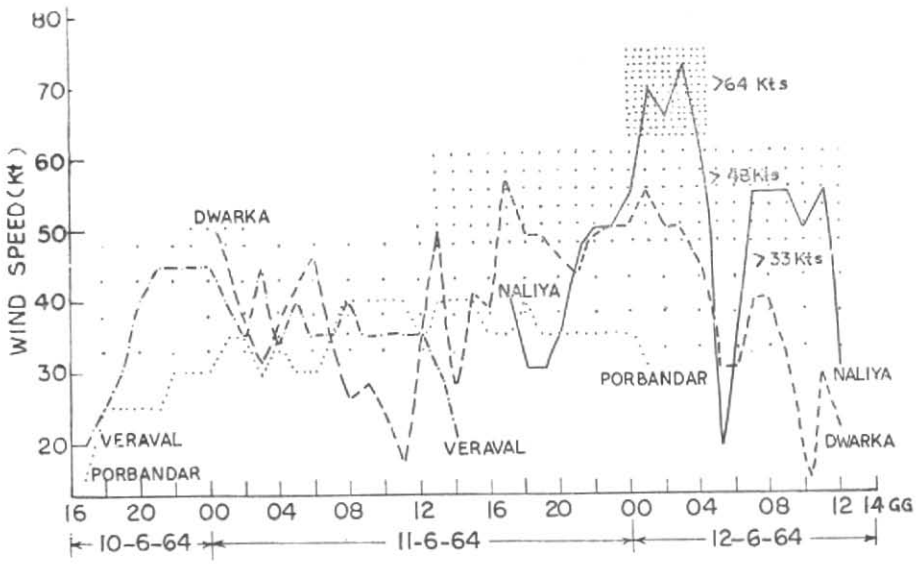

Fig. 6. Hourly variation of wind speed at the coastal stations of Veraval, Porbandar, Dwarka and Naliya

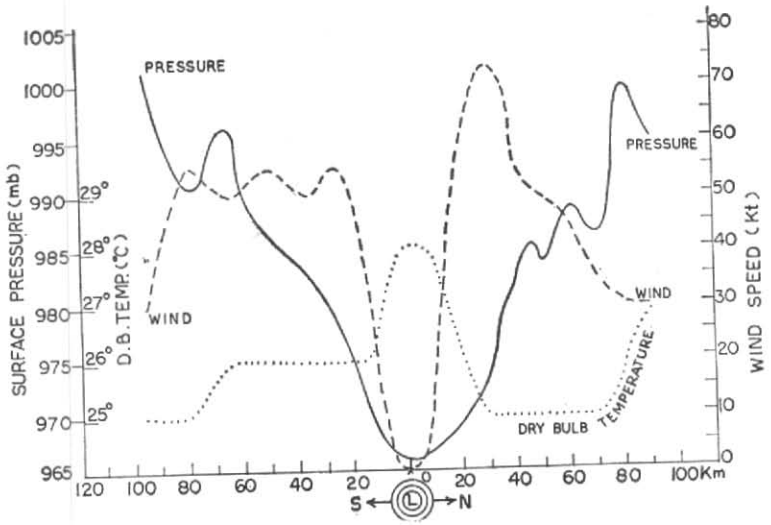

Fig. 7. Profiles of surface pressure, wind speed and dry bulb temperature of the severe cyclonic storm based on the hourly observations of Naliya

roughly northwest to southeast, the distance between the centre of the storm and the coast was getting reduced progressively. According to the information collected by the Meteorological Centre, Bombay the storm centre passed through the coastal village of Jakhau about 15 miles westsouthwest of Naliya. The winds which were blowing hard at Jakhau all through the night of 11th became calm by about 8 A.M. the next day and the sky cleared. Naliya also came within the central calm or weak wind zone of the storm. The surface wind at Naliya which reached the peak value of 73 kt at 03 GMT on 12th dropped to 18 kt at 05 GMT. The lowest surface pressure of 969·5 mb was recorded at this station at 0400 GMT. The corresponding pressure defect (departure from normal) is 32·5 mb which is about 3 per cent of the normal. This is of the same order as that found by Koteswaram and Gaspar (1956), in the case of a few cyclones which were known to have had calm centres.

4·2. The speed of movement of the storm was not uniform. The average speeds at 3-hourly intervals calculated for the period 06 GMT of 11th to 06 GMT of 12th from the position shown in Fig. 2 are given in Table 2. There was a decrease of speed between 09 and 15 GMT of 11th after which there was an increase followed by a further decrease. The storm was moving with the minimum speed of about 3 km/hr from 00 to 03 GMT of 12th, during which period it appears to have attained its maximum intensity with hurricane winds around its calm centre.

4·3. The pressure values and wind speeds recorded at Dwarka, Okha and Naliya when the storm was centred about 30 km away from these stations are given in Table

TABLE 2

Speed of movement of the severe cyclonic storm

Date	Time interval (GMT)	Average speed (km/hr)
11 June 1964	06—09	13·3
	09—12	6·7
	12—15	6·7
	15—18	10·0
	18—21	10·0
	21—24	6·7
12 June 1964	00—03	3·0
	03—06	13·3

TABLE 3

Station	Time	Pressure (mb)	Wind speed (kt)
Dwarka	18 Z of 11th	983·8	49
Okha	00 Z of 12th	984·0	40
Naliya	03 Z of 12th	973·2	73

TABLE 4

Sector of the storm	Winds	Approximate pressure limits (mb)	Pressure gradient (mb/km)	Dry bulb temperature (°C)
Area of 10 km radius round the centre	Calm or weak winds	< 970	—	about 28
Annular area between 10 and 20 km	Wind speed increases rapidly	—	—	—
Annular area between 20 and 40 km	Hurricane winds (greater than 63 kt)	970—982	0·6	25-26
Annular area between 40 and 55 km	Stormy winds (48-63 kt)	982—988	0·4	25
Annular area between 55 and 75 km	Gale winds (34-47 kt)	988—994	0·4	26-27

TABLE 5

Station	Radius of curvature (km)	Pressure gradient (mb/km)	Wind speed (kt)	
			Computed	Observed
Naliya	30	0·6	76	73
Dwarka	60	0·4	86	50
Veraval	260	0·04	46	41

3, which reveals a rapid intensification of the storm from 00 to 03 Z when it developed hurricane winds.

4.4. In the absence of information such as can be obtained by aircraft reconnaissance for getting a synoptic picture of the storm, the hourly observations recorded at Naliya and the corresponding positions of the storm centre which was moving close to Naliya have been made use of to construct the surface pressure, wind and temperature profiles of the storm shown in Fig. 7. Since the calm centre had been reported from Jakhau the wind profile has been completed accordingly. The right hand side of the profile refers to the northern sector of the storm, while the left hand side refers to the southern sector. It is possible that the latter does not depict the picture of the storm at its maximum intensity, as the storm had begun to weaken after 04 GMT on 12th.

4·5. The significant features of the storm as revealed by Fig. 7 are summarised in Table 4. As can be seen from Table 4, the storm field with gale winds and above was restricted to an area of about 150 km in diameter. The pressure gradient varied from 0·4 mb/km near the periphery to 0·6 mb/km close to the centre of the storm. It may be mentioned that Riehl (1954) has found that the mean pressure gradient in the field of tropical storms ranges from 0·3 mb/km to 1·3 mb/km. As mentioned in Table 1, the lowest pressure of 969·5 mb was recorded at Naliya when the storm centre was about 10 km away. Assuming the pressure gradient of 0·6 mb/km to prevail in the innermost core of the storm also, the central pressure works out to about 964 mb.

4.6. The observed temperature variations are interesting. In the advancing sector of the storm, the dry bulb temperature fell from about 27° to 25°C at a distance of 70 km from the centre and remained at that value upto about 30 km from the centre. In the inner sector of the storm, the temperatures rose again to about 28°C.

4.7. Assuming approximately a circular structure for the storm, it was considered to be of interest to see to what extent the observed winds at different distances from the storm centre were in conformity with the values computed from the well-known gradient wind equation—

$$v = -\frac{lr}{2} + \sqrt{\frac{l^2 r^2}{4} + \frac{r}{\rho}\frac{\partial p}{\partial r}}$$

where, l = Coriolis parameter ($2\omega \sin\phi$)

r = radius of curvature

ρ = density of the air

and $\partial p/\partial r$ = pressure gradient

For estimation of r and $\partial p/\partial r$, the isobaric chart shown in Fig. 4 was employed. The computed and observed winds for Naliya, Dwarka and Veraval at 0300 GMT on 12 June are given in Table 5.

The agreement between the observed and computed values of wind speed is satisfactory in respect of Veraval and Naliya. In the case of Dwarka, the computed value is higher than the observed value. The difficulty in the correct assessment of $\partial p/\partial r$ may be partly responsible for this.

5. Acknowledgements

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