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Some features of Porbandar cyclone of October 1975

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ABSTRACT. A severe cyclonic storm crossed Gujarat coast near Porbandar on the afternoon of 22 October 1975. This caused large scale damage in the northern parts of Gujarat State. A detailed study on different aspects revealed many features associated with this cyclone, *viz.*, possibility of a cycloidal motion in the trajectory of the storm centre, moisture release in the eastern sectors etc. Evaluation of different types of observation like the satellite pictures, cyclone warning radar observation, post flight reports etc have also been discussed.

1. Introduction

A severe cyclonic storm crossed the Gujarat coast near Porbandar at about 0930 GMT on 22 October 1975. This is the first time since 1877, that a severe cyclonic storm crossed the Gujarat coast in October though a cyclonic storm crossed this coast in October 1917. The severe cyclonic storm caused both intensive and extensive large scale damage in the Junagarh, Jamnagar and Rajkot districts of Gujarat State. The loss of human life has been placed at 85 and the loss of property including crops, buildings, stored food grains and other installations to the tune of rupees 75 crores. Several thousand houses collapsed. The fury of the storm was such that it had even blown a train off its rails, thereby causing disruption to rail traffic in the northern parts of Saurashtra for more than a week.

Rarity of severe storms in this area has made this storm important and interesting from the forecaster's point of view. It is for this reason that a detailed study of the storm was undertaken. A brief account of some of the noteworthy features associated with this cyclone are given in this paper.

2. Brief history of the severe cyclonic storm

A well marked low pressure area formed over central and adjoining south Bay of Bengal on the 15th morning which intensified into a depression, moved westnorthwest and lay centred at 0300 GMT of the 18th, about 50 km eastsoutheast of Ongole. At this time a low pressure area also formed over east central Arabian Sea with central region near 14·0°N, 73·0°E.

The depression in Bay crossed the Andhra coast near Ongole on the 18th afternoon, weakened into a low presure area and moved northwest to central parts of Madhya Maharashtra by 19th morning. The system over the Arabian Sea also moved northwestwards. The low pressure area over Madhya Maharashtra subsequently moved into the Arabian Sea between Harnai and Ratnagiri. The two systems merged together and concentrated into a depression by the evening of the 19th, centred about 75 km southwest of Harnai.

The depression intensified into a deep depression by the 20th morning and to a cyclonic storm by the evening of the 20th and continued to move northwestwards; it being centred at 0300 GMT of the 21st near 19·5° N, 69·0°E. The system then moved northnorthwest and concentrated into a severe cyclonic storm by the 21st evening. The 24-hour pressure change values started falling over stations in coastal Saurashtra from 2100 GMT of the 21st. The system intensified further into a severe cyclonic storm with a core of hurricane winds which lay centred near 20·8° N, 69·0° E at 0300 GMT of 22nd. The satellite picture of the 22nd morning (Fig. 9) showed a clear eye with an estimated diameter of about 30 km. The 24-hour pressure changes at Veraval and Porbandar at 03 GMT of the 22nd were —3·9 mb and —9·8 mb respectively, thus indicating that the system was heading towards Porbandar.

It was found by observations and discussions with local people by one of the authors (S. K. Subramanian) that the severe cyclonic storm had crossed the coast about 15 km northwest of Porbandar by about 0930 GMT of the 22nd. The lowest pressure recorded at Jamnagar was 979·5 mb at 1500 GMT of the 22nd which coincided with the period when easterly winds reached a maximum speed as high as 100 kt in gusts. The centre of the

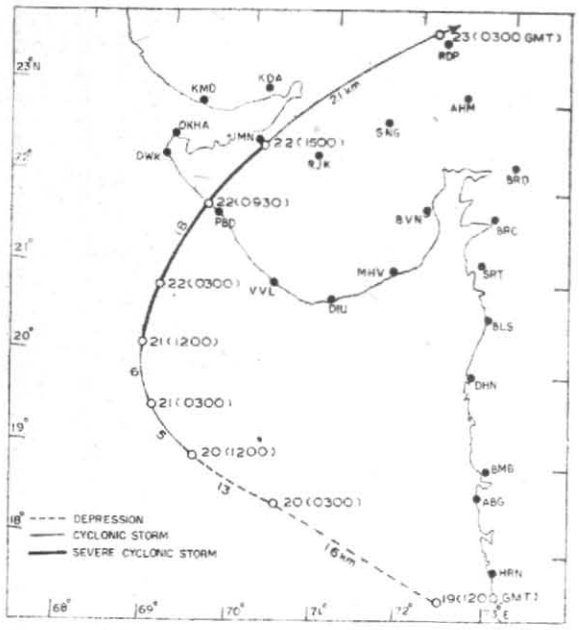

Fig. 1. Track of Severe cyclonic storm over the Arabian Sea on 19—23 October 1975

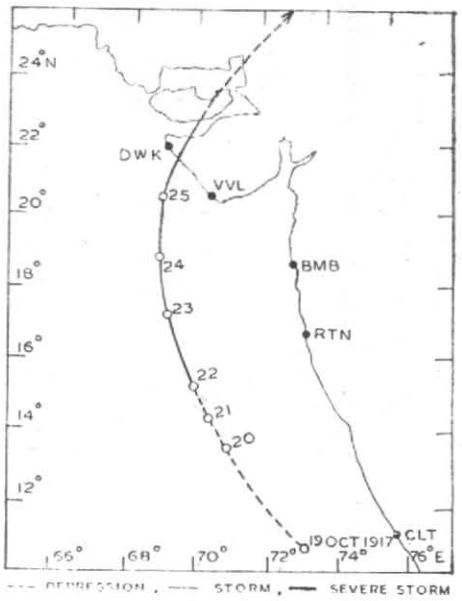

Fig. 1(a). Track of the Arabian Sea cyclonic storm of 19—26 October 1917

severe cyclonic storm might have passed by this time about 5 —10 km south of Jamnagar.

Khandla experienced strong winds from 1500 GMT onwards and the maximum speed recorded there was around midnight of 22nd/23rd. The system continued to move in a northeasterly direction, weakened in o a cyclonic storm and was centred near Radhanpur on the 23rd morning. It further weakened into a depression with centre near Kota on the 24th morning. It lay as a well-marked low pressure area over west U. P. by the 24th evening and became less marked on the morning of the 25th. The track of the severe cyclonic storm over the Arabian Sea is given in Fig. 1.

The cyclonic storm of 19 to 26 October 1917 was the only other system which had crossed Saurashtra coast from the west in October since 1877. The *Annual Weather Summary* and the *Indian Daily Weather Report* (India met. Dep. 1917) have been referred to for the details about the system which are given below:

Weather was disturbed in the southeast Arabian Sea on 18 October 1917 and a depression formed the next day with centre near 11° N, 73° E. Moving in a northwesterly direction, it intensified into a cyclonic storm on 22nd when it was about 400 km to the west of Goa. The storm moved initially northnorthwards and then northwards. After recurvature, it crossed coast between Dwarka and Veraval on the afternoon of the 25th. Moving northeastwards, it broke up against the hills of east Punjab. The intensity of the system increased on 24th and winds of force 8 to 9 on the Beaufort Scale, *i.e.*, 40 to 45 knots were reported on this day and the succeeding one. The barometric depression was 0·4" (13·55 mb).

The track of the system is given in Fig. 1(a).

3. Discussion

(a) *Intensification and direction of movement*

The upper air features gave clear indications on the intensification and the direction of movement of this severe cyclonic storm. The chart for 500 and 250 mb levels were selected and analysed, the former indicative of the presence of troughs in upper troposphere and the latter representing the position of the ridge at higher levels which normally govern the direction or movement of the storm. 250 mb level was preferred to 200 mb level because of better data coverage, as a large number of aircraft reports were available at this level on the days under consideration.

The low pressure area over central parts of Madhya Maharashtra emerged into the east central Arabian Sea and intensified into a depression on the 19th evening. The upper air chart of 500 mb at 12 GMT of the 19th (Fig. 2) indicated pronounced moisture feed from both the Bay of Bengal and the Arabian Sea in the lower and middle troposphere favouring further concentration of the depression. The system accordingly intensified into a deep depression.

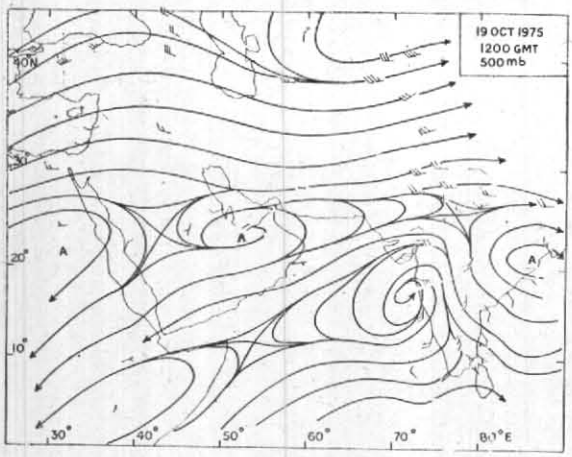

Fig. 2

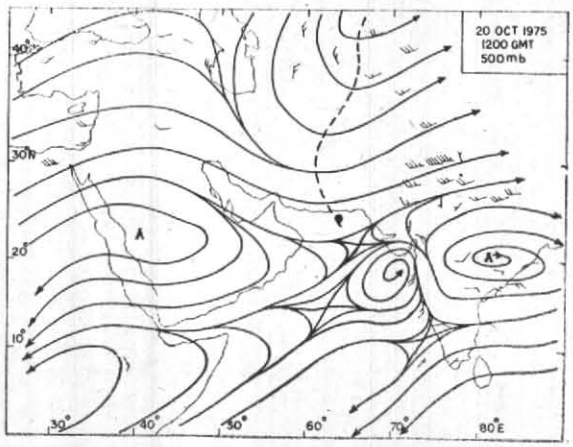

Fig. 3

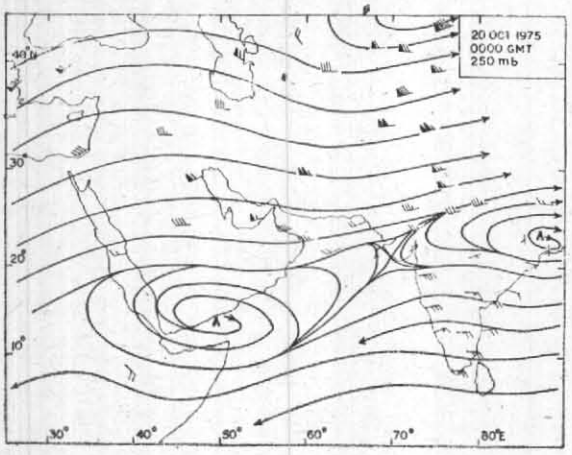

Fig. 4

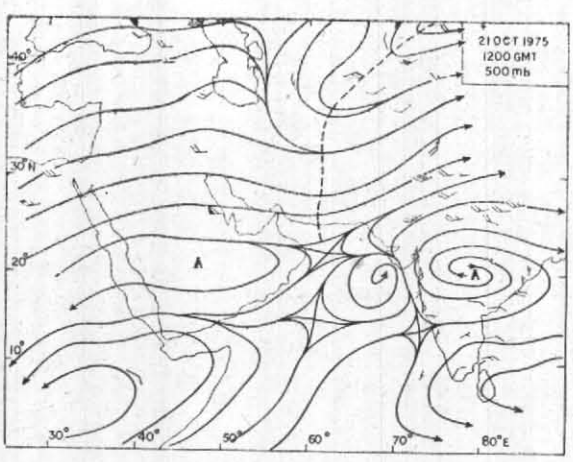

Fig. 5

It further concentrated into a cyclonic storm possibly under the influence of a trough in the westerlies extending upto north Arabian Sea, as could be seen from the 12 GMT upper air chart of the 20th for 500 mb level (Fig. 3). On 21st morning the system was centred near 19·5°N, 69·0°E. The Col region at 250 mb level at this time was overlying the cyclonic storm (Fig. 4), thus indicative of a decrease in speed of movement. The approach of another westerly trough noticed along Long 62°E at 500 mb level of 1200 GMT of the 21st (Fig. 5) caused the system to intensify further into a severe cyclonic storm. This trough shifted to Long. 65°E at 00 GMT of the 22nd (Fig. 6) and the southward shift of the Col region was noticed at 250 mb level (Fig.7). This indicated that the system had moved northeastward after recurvature, the intensity however remaining the same.

Thus the intensification of the system was seen in association with (1) pronounced moisture feed from the Arabian Sea and the Bay of Bengal and (2) the approach of the trough in the westerlies which extended southwards upto north Arabian Sea. When the system was directly below the Col region at 250 mb level the movement was very slow with somewhat northerly direction. The general direction of movement was northwesterly when the centre of the system was to the south of the Col region and northeasterly when the centre was to its north thereby following more or less the peripheral path of the anticyclone at 250 mb level.

(b) *Central pressure associated with the severe cyclonic storm*

The hourly pressure and wind values recorded at Porbandar and Jamnagar are given in Fig. 8. As the centre of the severe cyclonic storm had not crossed right over Porbandar or Jamnagar the changes in wind direction with the time of

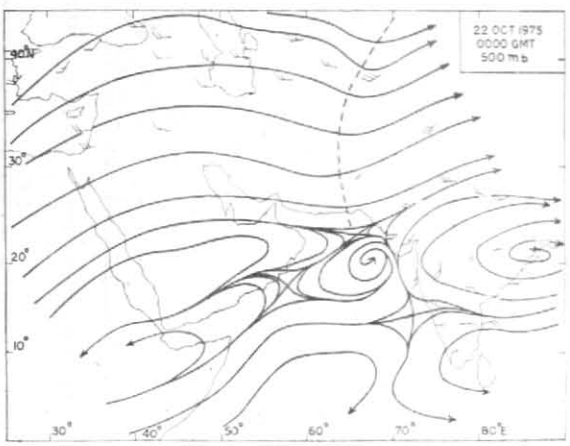

Fig. 6

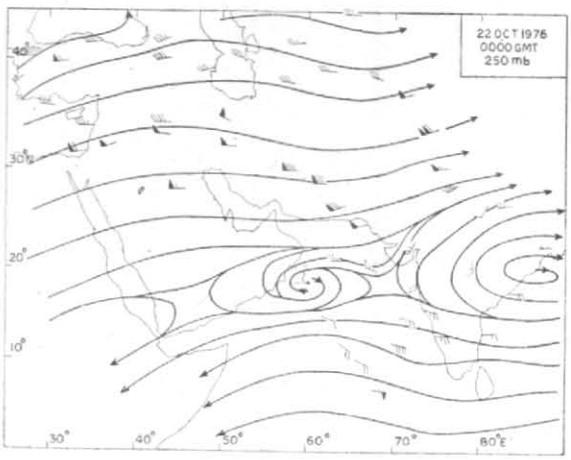

Fig. 7

TABLE 1

Surface wind observations recorded on 22-23 October 1975

Time (GMT)	Veraval		Porbandar		Dwarka		Okha		Jamnagar		Rajkot		Kandla	
	dd	ff	dd	ff	dd	ff	dd	ff	dd	ff	dd	ff	dd	ff
0000	140	37	090	20	070	09	110	12	110	10	140	13	090	17
0100	140	38	090	20	070	15	110	10	110	10	..	..	070	18
0200	140	40	090	19	070	12	110	11	100	10	..	..	070	14
0300	160	41	090	20	070	12	110	23	090	12	140	16	070	17
0400	160	40	120	22	Clam		110	15	090	10	..	..	070	16
0500	160	43	090	36	050	15	090	28	090	15	..	..	070	12
0600	160	42	110	36	050	18	090	27	090	18	110	18	070	16
0700	180	43	110	32	070	20	090	26	080	18	..	..	070	16
0800	180	44	140	44	020	31	090	35	090	25	..	..	020	16
0900	180	36	230	49	xx	xx	070	39	090	25	140	18	020	17
1000	180	43	200	53	360	25	070	49	090	27	140	21	090	19
1100	230	32	230	53	360	36	050	44	090	30	140	24	020	17
1200	230	35	270	49	360	28	050	54	090	30	140	24	020	21
1300	250	32	270	28	340	21	050	50	090	40	140	24	020	29
1400	250	27	..	..	340	18	020	32	090	85	140	26	020	33
1500	250	27	..	..	340	18	360	42	090	100	140	26	020	40
1600	270	24	..	..	320	15	360	36	090	70	140	32	020	45
1700	270	25	..	..	320	06	020	30	090	50	140	48	340	47
1800	270	20	..	..	320	06	360	32	090	60	140	43	340	54
1900	270	20	..	..	290	06	360	17	040	50	160	48	340	52
2000	270	20	..	..	290	09	360	17	040	50	160	35	290	43
2100	290	20	..	..	290	06	340	16	360	40	180	34	290	35
2200	290	15	..	..	270	12	340	18	360	40	230	26	290	32
2300	..	..	..	..	270	12	340	15	360	45	230	26	290	32
0000	..	..	..	..	270	12	340	12	360	40	270	30	290	27
0100	..	..	..	..	..	..	340	14	360	15	..	..	290	22

dd : Direction of wind (in degrees)

ff : Speed of wind (in knots)

occurrence of the pressure minimum could not clearly be explained. Though the lowest pressure recorded at Porbandar was 972.2 mb one can very well imagine, considering the severity of the system, that the lowest pressure recorded at the point where the system actually crossed the coast may even be very much less.

(c) *Speed of movement*

The speed of movement of the severe cyclonic storm in kmph are indicated between positions along the track given in Fig. 1. It may be seen that the speed of movement of the system was not uniform. The following peculiarities were noticed:

(*i*) In the initial stages the speed of movement reduced with the intensification of the system, *i.e.*, from 16 to 5 kmph. (*ii*) Near the point of curvature the speed of movement was a minimum (5 - 6 kmph). (*iii*) After recurvature the speed of movement again increased, the speed at the time of crossing the coast was 18 kmph. (*iv*) The speed of movement again increased after the storm had crossed the coast.

(d) *Structure of the severe cyclonic storm*

Similar to all types of tropical stormes this system also had all the features like the inner calm area, inner storm area, outer storm area etc. People at Porbandar .P. (6 km to the south of Porbandar City) and Viswada (about 20 km north of Porbandar City) experienced for a short time (15-20 minutes) the passage of the eye of the system in the form of sudden brightness in the sky, though the sky remained overcast, and a slight reduction in wind speed around 0930 GMT on the 22nd. Areas to the north and south of this not experiencing such phenomena indicates that Porbandar A.P. and Viswada were in the southern and northern edge of the inner calm area, *i.e.*, the eye of the system had a diameter of about 25 km. This agreed well with the estimate of the diameter of the eye of about 30 km from satellite pictures and mentioned in the post flight reports of aircraft reporting eye with well defined edge having diameter of about 15-20 miles.

For estimating the inner storm area we first define the criteria as wind speed of more than 40 kt. The ESSA-8 satellite picture of 22nd morning (Fig. 9) indicated the central cloud mass of the system as elliptical and not circular and before striking the coast the orientation of the major axis of this elliptical cloud mass was north-south. The hourly wind observations of Veraval, Porbadar, Okha, Jamnagar and New Kandla are given in Table 1. It may be seen that at the time of the

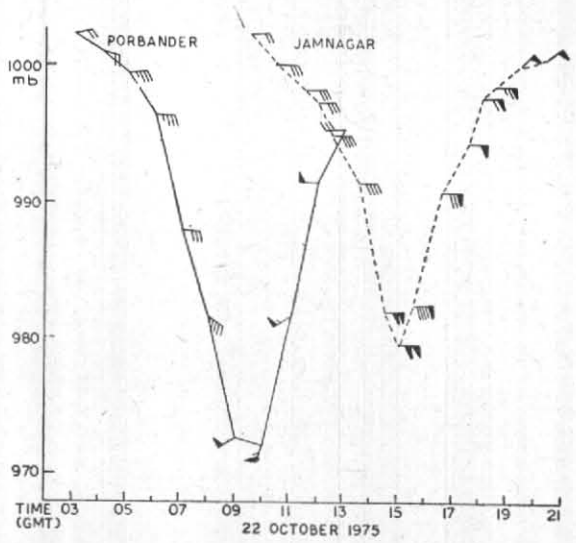

Fig. 8. Hourly pressure and wind observation recorded at Porbandar and Jamnagar on 22 October 1975

Fig. 9. ESSA-8 Satellite picture received at Bombay APT on 22 October 1975

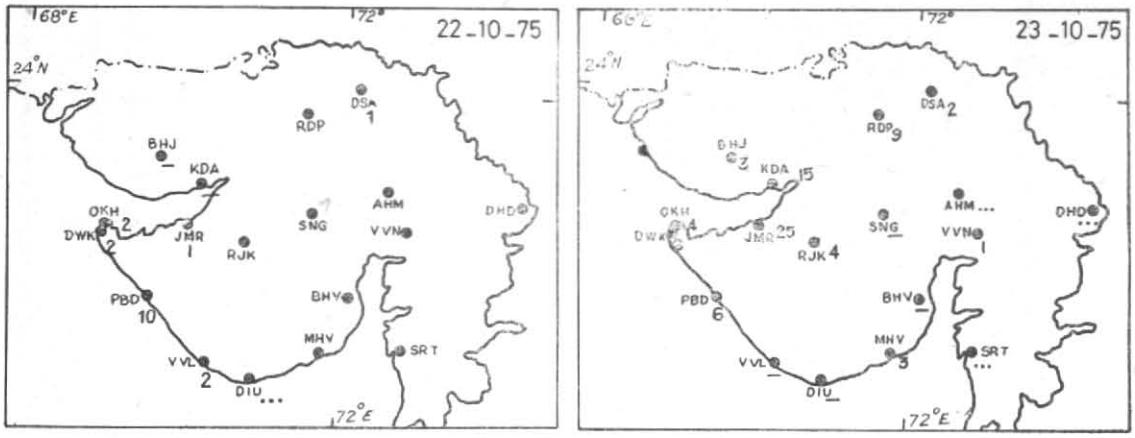

Fig. 10. Rainfall map of Gujarat State as recorded on 22 and 23 October 1975

cyclone crossing the coast both Veraval and Okha which are about 110 km away from Porbandar, were experiencing wind speed of more than 40 kt from southerly and eastnortheasterly direction respectively. Thus as an estimate the major axis or the north-south diameter of the inner storm area can be taken to be about 220 km.

After crossing the coast the system moved in a NNE'ly direction and the comparison of the hourly wind observations of Jamnagar, Porbandar and Okha shows that when wind speeds at Jamnagar started increasing to more than 40 kt after 13 GMT, the winds at Porbandar had already slowed down to 28 kt and windspeeds at Okha decreased to 32 kt from 14 GMT onwards. This indicates that the minor axis or the east-west diameter of the inner storm area may be estimated to about 100 km. In the absence of such observations further to the north and south the estimate of the diameter of the outer storm area could not be made. These estimates are only rough and have to be taken with some reservation because the winds in the northern sector of post monsoon cyclones are generally higher as compared to winds in other sectors.

(e) *Rainfall distribution*

The rainfall distribution caused by this system was assymetrical. Generally the forward sectors got more rainfall than the other sectors. The 24-hour rainfall recorded at 0300 GMT on 22nd at Porbandar was 10 cm, *i.e.*, when the system was about 110 km southsouthwest of the station, and the corresponding rainfall amount on the 23rd was only 6 cm. Similarly Jamnagar recorded 7·9 mm for the 24-hour period ending at 0300 GMT on 22nd and 51·2 mm during the period from 0300 to 1200 GMT on 22nd and 190·0 mm during 1200 GMT to 1800 GMT on 22nd and only 4·8 mm for the remaining period till 0300 GMT on 23rd.

The SRRG chart of Kandla Observatory showed that about 12 cm of rainfall fell during the period from 1615 IST of the 22nd to 0040 IST of the 23rd; the rainfall recorded between 0300 and 1200 GMT on the 22nd being only 29·0 mm and for the 24-hour period ending at 0300 GMT of the 23rd being 146·2 mm.

Thus the forward sectors of the system received significantly large amount of rain as compared to other sectors. The 24-hour rainfall recorded at 0300 GMT on 22nd and 23rd by the stations in Gujarat State are given in Fig. 10.

(f) *Release of moisture after the system crossing the coast*

When the system was out in the sea the radarscope pictures taken by the cyclone warning radar at Bombay showed only a small portion of the outermost spiral band which got separated from the main system after the cyclone entered land and it gradually moved eastwards. The radarscope picture taken on 23rd morning is given in Fig. 11. This moisture release caused good rainfall over north Konkan and south Gujarat region. This type of release of moisture occurs generally in the eastern sector of a north or northeastward moving system as mentioned by Petterssen (1956), while discussing some typical trajectories of air parcels in the vicinity of a moving cyclonic centre, specially when the speed of movement of the centre of the system is less than the wind velocity in the outer periphery of the cyclonic wind field. Mukherjee *et al.* (1956) have discussed similar mechanism in causing heavy rainfall over coastal Andhra Pradesh under the influence of westward moving storms in the Bay of Bengal.

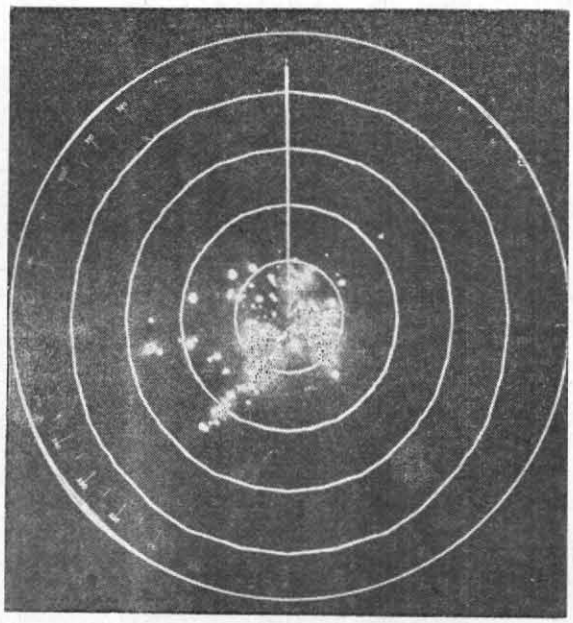

Fig. 11. Radarscope picture taken by the Cyclone Warning Radar at Bombay on 23 October 1975 at 0237 GMT

4. Evaluation of different observations

(a) *Satellite pictures*

When ships' observation from the field of disturbance were either absent or very meagre, the satellite pictures mainly provided required information regarding the location and classification of the system. In the initial stage, when the system had not fully developed, the estimate of the centre based on satellite pictures was different from the one that could be fixed by conventional method. This may be due to the fact that the satellite pictures give an idea about the location of the centre at the level of mean cloud height which may not necessarily coincide with the surface centre. Also when the system was recorded on the edge of the picture the confidence of the estimate of the centre was poor and hence this may also cause a difference when compared with the surface centre. But when the system had fully developed there was good agreement with the surface centre and the centre as fixed by the satellite pictures.

(b) *Cyclone warning radar observations*

In the early stages when the system was near the coast the complete cloud-line structures were seen on the radarscope of the cyclone warning radar at Bombay. The location of the disturbance and its direction of movement could be traced from successive observations. As the system was moving away northwestwards, in later stages, only a small portion of the outermost spiral band could be seen and the centre could not be estimated with full confidence.

After the system crossed the coast the outermost band got separated and moved eastwards and was tracked very clearly by the radar till its final dissipation (Fig. 11). Such types of release of moisture occurring in the eastern portion of a north or northeastward moving system, as explained earlier, sometimes may confuse the forecaster to think that the system itself is moving rapidly, whereas actually it is only the outermost banding of the system that is moving.

(c) *Post flight information received from aircraft*

At times when the ships' observations were completely absent and during the periods when there were no reception of satellite pictures the post flight reports given by the aircraft crew, though not fairly accurate, regarding characteristic of the eye, nature and the vertical extent of cloud in association with the disturbance etc. were quite helpful.

5. Conclusion

The cyclonic storm which crossed Gujarat coast near Porbandar on 22 October 1975 revealed many features. The intensification of the system was caused in association with (i) pronounced moisture feed in the lower troposphere from the

Arabian Sea and the Bay of Bengal and (ii) the approach of the trough in the westerlies, which extend southwards upto north Arabian Sea. The Col region at 250 mb level influenced the direction and speed of movement of the system. The forward sectors of the system received significantly large amount of rainfall as compared to other sectors. The release of moisture in the right sector was also prominently seen in this case.

Acknowledgements

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REFERENCES

India met. Dep. 1917 *Annual Weather Summary.*

Mukherjee, A. K., Mooley, D. A. and Natarajan, G. 1966 *Indian. J. Met. Geophys.*, **17**, Spl. No., pp. 133-146.

Normand, C. 1926 *Storm Tracks in the Arabian Sea*, India met. Dep. Publ.

Petterssen, S. 1956 *Weather Analysis and Forecasting*, **1**