

Cyclones and depressions in the Indian seas in 1976

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1. Introduction

Ten cyclonic storms and three depressions formed in the Bay of Bengal and the Arabian Sea during the year, while a depression developed over land. The cyclonic storm activity in the post-monsoon season (October to December) of 1976 was much above normal, with 7 storms and depressions as against the long term average of 5 disturbances. The activity was practically confined between mid-October and end of November which accounted for 6 out of the 7 disturbances. The last storm of the season was towards the end of December which is a rare occurrence. The activity was normal in the pre-monsoon season (March to May). The first half of the monsoon season was marked by a complete absence of depressions in the Bay of Bengal. The first depression of the monsoon season formed only on 28 July and that too over land, quickly followed by another over the north Bay on 1 August. The tracks of these cyclonic storms and depressions are shown in Fig. 1. Their monthly distribution is given in Table 1(a). The maximum winds and the minimum sea level pressure associated with the storms are given in Table 1(b).

The main features of this year's cyclonic disturbances were :

- (i) Of the ten cyclonic storms, four developed a core of hurricane winds.
- (ii) Five storms had a westerly to northwesterly track and three mainly a northerly track. The remaining two recurved.
- (iii) Most of the storms were of small size with the area of winds of gale force confined to less than a degree from the storm centre.
- (iv) Practically all the disturbances that formed in the Bay of Bengal could be traced backwards to south China Sea or even southwest Pacific.

- (v) Parts of Gujarat State, Gangetic West Bengal and Andhra Pradesh suffered considerable damage due to cyclonic storms.
- (vi) The Contai cyclone in September and the Masulipatnam cyclone in November retained their storm intensity over land for more than 500 km.
- (vii) The severe storm which hit the Bay islands towards the end of December was a very rare occurrence. It also gave an all time record rainfall at some of the islands and caused some damage in Little and South Andaman.
- (viii) The deep depression which moved from north Bay to Himachal Pradesh in the middle of August attained the intensity of a cyclonic storm temporarily when it was close to Delhi.

A brief history of the cyclonic storms and depressions together with the important features associated with them is given in Section 2.

2. Brief history

2.1. Bay of Bengal

(1) Severe cyclonic storm, 29 April to 2 May

This was the first storm of the year and it followed the normal track for the season.

Satellite pictures showed appearance of a widely scattered belt of convection in the extreme southern parts of the Bay of Bengal and Arabian Sea on 22 April. The clouding gradually became dense and in this belt of heavy clouding, a low pressure area formed over Andaman Sea on 24th. It moved to southeast Bay on 26th and persisted there upto 28th. Under the influence of another low pressure wave moving westerwards across Andaman Sea,

TABLE 1(a)

Monthly distribution of cyclones and depressions in the Bay of Bengal and Arabian Sea, 1976

	Jan-Mar	Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Annual total	
		D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C
Bay of Bengal	—	—	1(1)	—	—	—	—	—	—	2	—	—	1(1)	—	1	—	3(2)	—	1(1)	2	7(5)
Arabian Sea	—	—	—	—	1(1)	—	—	—	—	—	—	—	1	—	1(1)	1	—	—	—	1	3(2)
Over land	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Total	—	—	1(1)	—	1(1)	—	—	1	—	2	—	—	2(1)	—	2(1)	1	3(2)	—	1(1)	4	10(7)

D = Depression, C = Cyclonic storm, Figures in brackets indicate the cyclonic storms which had become severe

TABLE 1(b)

Cyclonic disturbance	Wind (kt)		Pressure (mb)	
	Maximum estimated from satellite picture	Maximum reported from nearest land station or ship	Estimated lowest m.s.l. pressure at the centre	Lowest m.s.l. pressure reported from nearest observatory/ship
Severe cyclonic storm (29 Apr-3 May)	60	50 (Basscin)	986.0	989.3 (Sandoway)
Mahuva cyclone (29 May-5 Jun)	70	90 (ONGC ship <i>Hakon Magnus</i>)	970.0	981.0 (ONGC ship <i>Shenon Dabay</i>)
Cyclonic storm (27 Aug-8 Sep)	40	45 (Okha)	990.0	990.4 (Naliya)
Contai cyclone (8-19 Sep)	70	70 to 80 (Sandheads and Sagar Island)	977.0	973.0 (Sagar Island very close to storm centre)
Severe cyclonic storm (12-18 Oct)	55	27 (Ship <i>ATIV</i> about 300 km south-west of storm centre)	998.0	—
Cyclonic storm (15-21 Oct)	45	45 (Ship <i>Jameela</i> 50 km from storm centre)	994.0	998.0 (Ship <i>Jameela</i>) 996.7 (Hatia in Bangla Desh)
Masulipatnam cyclone (3-6 Nov)	65	55 (Gannavaram)	987.0	985.0 (Masulipatnam)
Kavali cyclone (15-17 Nov)	60	38 (Ship <i>UYJE</i> about 00 km from storm centre)	992.0	—
Cyclonic storm (22-29 Nov)	40	40 (Gannavaram at 0.9 km a.s.l.)	1000.0	—
Severe cyclonic storm (28 Dec-3 Jan)	80	75 (<i>INS Sakti</i> at Port Blair)	981.0	989.0 (<i>INS Sakti</i>)

(2) *Deep depression, 1-3 August*

After the severe cyclonic storm crossed Arakan coast early in May, the Bay of Bengal was rather quiescent for nearly three months, till a depression formed on the morning of 1 August over north-west Bay. This long absence of cyclonic disturbances in the Bay led to continued deficit rainfall in many States which lie in the normal track of monsoon depressions. The monsoon rainfall in Gangetic West Bengal, Orissa, Bihar, east Uttar Pradesh, east Madhya Pradesh were in defect upto about 40 per cent by the end of July.

The origin of this depression could be traced backwards to tropical storm 'Violet' which formed in south China Sea on 20 July and crossed south China coast to the south of Hongkong on 25th night. Interestingly, tropical storm 'Violet' was the first storm of the season to form in the south China Sea and was also the first one in the Pacific to move towards the Asian mainland and cross the south China coast. Although the storm weakened rapidly on entering land, it could be clearly traced in the upper air (upto 500 mb) moving in a southwesterly direction. The circulation emerged into north Andaman Sea and Gulf of Martaban area on the morning of 29 July. Tropical storm *Violet* was practically obliterated on the surface chart during its movement across the Indo-China Peninsula, but the isobaric charts give some evidence of the system.

The upper air circulation thereafter moved north-westwards to central Bay and also built downwards and a low pressure area formed by 30th morning. As the low moved to northwest Bay, rapid intensification took place, and it lay as a deep depression off Orissa coast on the morning of 1 August and crossed coast near Paradip the same night. The depression moved to Madhya Pradesh on 3rd and weakened into a low on 4th over north Madhya Pradesh.

Satellite pictures showed that the clouding was not much over most of the Bay from 25 July. However, as upper air low entered the Andaman Sea on 29th, heavy clouding commenced over most of central and south Bay in the belt of low level westerlies.

This system caused generally widespread rain in Orissa, coastal Andhra Pradesh and Gangetic West Bengal from 1st to 3rd and in Madhya Pradesh, Vidarbha and Telangana from 2nd to 4th, with heavy to very heavy falls in Orissa on 1st and 2nd and in Madhya Pradesh and Vidarbha on 3rd and 4th. Floods in the *Narmada* and the *Indravathi* disrupted road communications in Madhya Pradesh. Some parts of Bolangir and Koraput districts were also affected by floods.

(3) *Deep Depression, 12-18 August*

Like the previous depression, this also developed from the remnants of tropical storm "Clara" which formed in the south China Sea and crossed south China coast south of Hongkong on the night of 6 August almost at the same place as the earlier tropical storm "Violet".

The depression had only a short life over the Bay. It formed as a depression over north Bay on the morning of 12th, became deep the same evening and crossed Orissa coast between Balasore and Contai on the early morning of 13th. It had a longer track over land and it temporarily attained cyclonic storm intensity on the morning of 18th when it was near Delhi.

Low level winds (upto 700 mb) associated with the system reached 30 to 35 kt on most days from 12 August. However, the number of closed isobars (at 2 mb interval) around the storm centre was only 2 or 3 till 17th. On the morning of 18th (at 0300 GMT), rapid intensification took place and at least seven closed isobars at 2 mb intervals could be drawn. Pressure fell by about 10 mb over New Delhi between 1500 GMT of 17th and 0300 GMT of 18th and the lowest pressure of 988.4 mb was recorded at 0300 GMT of 18th when centre of the storm was close to Delhi. The pressure departure at that station was *minus* 12 mb at this time.

The 10 cm radar at Calcutta located the centre of this system near 21.5°N, 87.5°E at 1500, 1600 and 1700 GMT on 12th. The radar at Delhi showed the spiral bands associated with this system and located the centre about 50 km to the north of Delhi on the morning of 18th. The 'eye' was also seen in the radar for a few hours on the 18th. A satellite view of the storm near Delhi is given in Fig. 3.

The deep depression had many special features. The track of the depression over the country was at a more northerly latitude for the month. Its intensification into a cyclonic storm and its recurvature took place under the influence of a westerly trough which moved across the extreme north of the country between 15th and 18th. The shift of the rain belt to the north of the track on 18th was characteristic of the recurring depressions.

In association with this system, generally widespread rain occurred in Gangetic West Bengal, Orissa and Bihar Plateau from 12th to 14th, in Madhya Pradesh from 13th to 16th, in Uttar Pradesh from 14th to 19th, in Rajasthan from 15th to 18th, in Gujarat region from 15th to 17th, and in Himachal Pradesh, Punjab and Haryana from 16th to 19th. Very heavy rain occurred in Orissa on 13th and 14th, in Madhya Pradesh from 8th to 16th, in east Rajasthan on 16th and 17th, in west

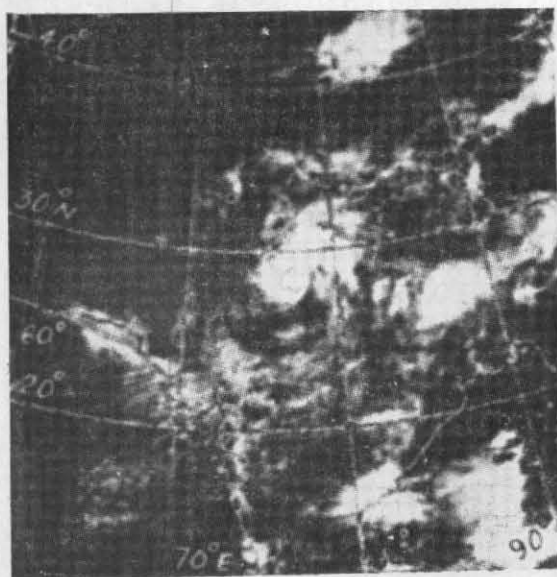


Fig. 3. Satellite view of cyclonic storm near Delhi on the morning of 18 August

Uttar Pradesh and Haryana on 18th and 19th. According to press reports heavy rain caused house collapses in Gwalior and disrupted road communications between Gwalior and other places. Serious floods affected Bharatpur, Dholpur and Alwar districts in Rajasthan and in many districts of west Uttar Pradesh and Haryana including Delhi, leading to considerable damage to crops, houses and public utilities in these areas. Some trees were uprooted in Delhi due to strong winds.

(4) Contai severe cyclone, 8-19 September

In the first week of September, the monsoon trough was well defined and extended from north Arabian Sea to the south China Sea and south west Pacific across the central parts of India. In this, a well marked low pressure area moved from Gulf of Siam northwestwards to east central Bay off south Arakan coast between 2nd and 7th. It concentrated into a depression on the morning of 8th with its centre near 17.5°N , 92.5°E . Moving northwestwards it became deep on 9th and further intensified into a severe cyclonic storm on the morning of 10th near 20°N , 90°E , when the satellite reported an 'eye'. But for the satellite report, there was no other observation available to judge the intensity of the disturbance. The storm was first seen by the cyclone warning radar at Calcutta by 1300 GMT of 10th when it was 300 km southeast of Calcutta.

Continuing to move northwestwards, the storm crossed West Bengal coast near Contai at about noon on 11th and weakened into a cyclonic storm

that night. This system retained its storm intensity over land upto 13th morning when it was located about 50 km southeast of Allahabad. Thereafter the storm weakened, recurved and moved southeastwards slowly as a deep depression and dissipated by 19th evening over Bihar Plateau and adjoining Gangetic West Bengal.

This storm had a core of hurricane winds on 10th and 11th as revealed by satellite pictures and the surface wind reports of 70 to 80 kt from Sagar Island and Sandheads.

As seen in the radar at Calcutta, the 'eye' was ill defined till about the midnight of 10th after which it became clear. It was nearly circular with a diameter of about 50 km. Although the 'eye' was clearly visible on the radar scope for a long duration, the rain shield was not well developed. It maintained the main structural features, *viz.*, 'eye' and spiral bands, well beyond landfall.

In association with this system, very heavy rain was reported from Orissa and Bihar on 12th, in east Uttar Pradesh from 13th to 15th and again in Bihar State from 15th to 18th. Considerable damage was caused by the cyclone in the coastal areas of Midnapore and 24-Parganas districts of West Bengal and in the northern parts of Balasore district of Orissa. About 40 persons lost their lives and 4000 heads of cattle perished in these areas. Many trees and telephone posts were uprooted. Several thousands of houses were damaged. Tidal waves of 2 to 3 m inundated coastal areas of 24 Parganas and Midnapore districts. Crops in about 1.25 lakh acres were damaged. As the system recurved and moved very slowly over east Uttar Pradesh and Bihar, very heavy rain in the eastern districts of Uttar Pradesh and many parts of Bihar for 3 to 4 days continuously, caused serious floods in these areas resulting in damage to crops and houses in these two States. Road and rail communications were dislocated in Bihar and the eastern districts of Uttar Pradesh. Patna district was the worst hit. Gaya reported an all time record rainfall of 29 cm on 16th.

Sagar Island and Sandheads reported maximum surface winds of 70-80 kt on 11th. The maximum in gusts reached 160 kmph (85 kt) at Sagar Island on 11th by about noon. These two stations also reported the maximum pressure departure from normal, *viz.*, minus 26 to 27 mb on 11th. The lowest pressure near the centre of the storm recorded at Sagar Island was 971.5 mb, on the morning of 11th. The hourly values of pressure and wind reported by Sagar Island on 11th are depicted in Fig. 4.

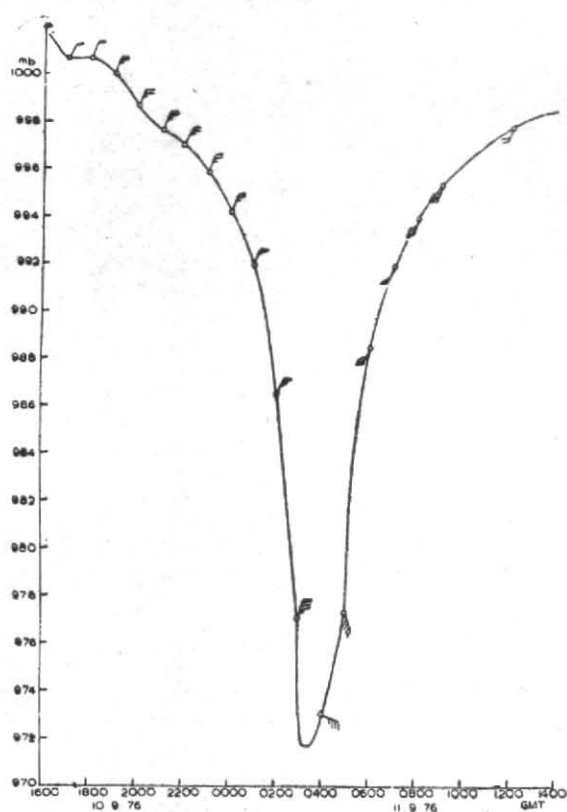


Fig. 4. Observations of wind (kt) and pressure (mb) at Sagar Island

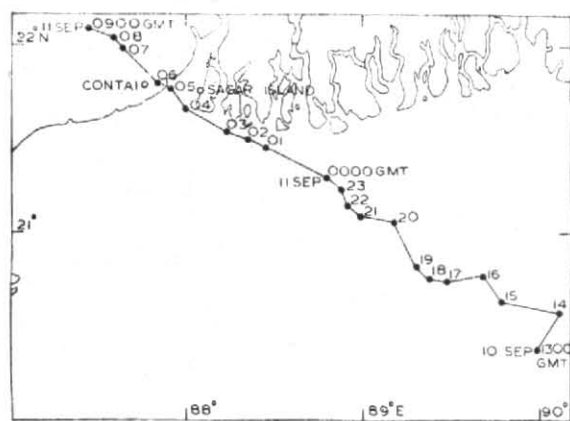


Fig. 5. Radar track of severe cyclonic storm, 10-11 September 1976

This storm was tracked by the Cyclone Warning Radars at Calcutta and Paradip. The path of the storm as tracked by Calcutta radar is reproduced in Fig. 5. Fig. 6 (a) shows the radar view of the storm at 0100 GMT on 11 September 1976 from Calcutta and Fig. 6 (b) radar view of the same storm from Paradip about the same time. The satellite cloud

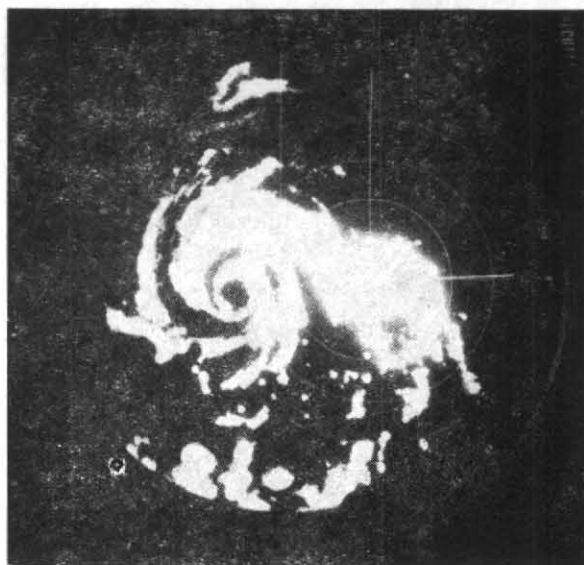


Fig. 6(a). Picture of Contai cyclone at 0100 GMT on 11 September taken by Cyclone Warning Radar, Calcutta



Fig. 6(b). Picture of Contai cyclone at 0000 GMT on 11 September taken by Cyclone Warning Radar, Paradip

picture of this storm showed an 'eye' on 10th and 11th. The cloud picture of this storm as viewed by NOAA-4 satellite on 11th morning is reproduced in Fig. 7. The maximum wind estimated from this satellite picture was 70 kt. The pressure at the centre of the storm for a maximum wind of 80 kt based on Fletcher's formula works out to be 977 mb,

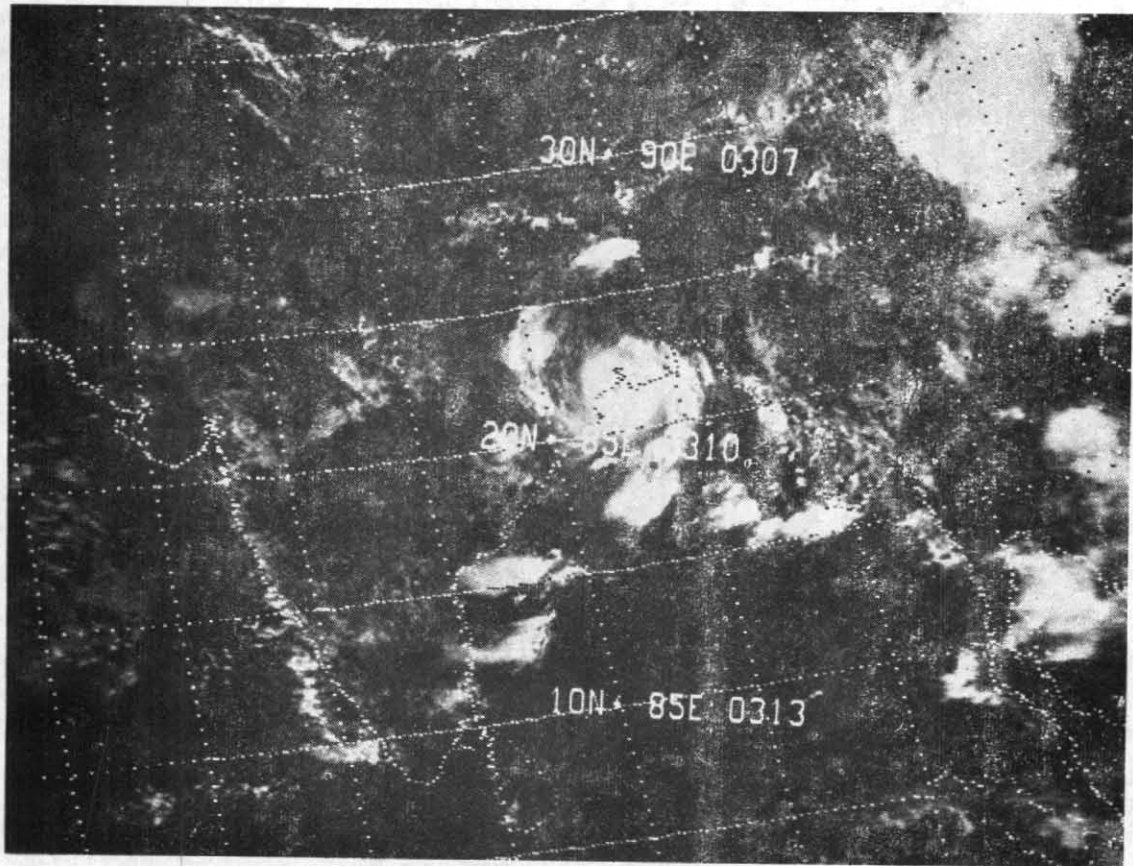


Fig. 7. Satellite view of Contai cyclone at about 0300 GMT on 11 September showing the eye of the cyclone

while the actual pressure reported was 971.5 mb on 11th by Sagar Island near the storm centre.

(5) *Cyclonic storm, 15-21 October*

By the beginning of the second week of October the seasonal trough became well marked extending from south Arabian Sea to Malaya Peninsula. Along this trough a low pressure area moved westwards from Malaya Peninsula and neighbourhood and entered south Andaman Sea on 12th.

Port Blair upper winds strengthened significantly by 14th and during the next 24 hours the winds along the east coast of the Peninsula also came into the grip of the circulation.

Taking a northwesterly course, the depression intensified and by about mid-day of 16th, it became a cyclonic storm centred near 12.5°N, 82.5°E, as indicated by the upper winds over Madras and Karaikal which reached upto 40/50 kt at 0.9 km a.s.l. and ship *Jameela* (position : 60 miles, SSE of Madras) reporting northwesterly BF 8-9, waves 5 to 6 m and pressure of 998 mb at 0930 GMT.

Subsequently as the storm weakened into a deep depression, it slowed down and recurved. By the 18th morning the recurvature was complete. Thereafter it speeded up and reintensified into cyclonic storm on the morning of 20th when it was located near 20°N, 88.5°E.

The reintensification of this system into a storm was indicated by satellite pictures and low pressures reported by coastal stations in Bangla Desh on 20th. The storm crossed Bangla Desh coast near Chittagong in the early hours of 21st and weakened into a low over north Burma the same evening. Chittagong reported winds of 35 kt from east-southeast at 1800 GMT of 20th.

In association with this system, widespread rain with heavy to very heavy falls occurred in north Tamil Nadu on 16th and 17th, in coastal Andhra Pradesh and Rayalaseema on 17th and 18th and in Orissa from 18th to 20th. Sulerpet and Nellore recorded exceptionally heavy falls of 41 cm and 32 cm respectively on 17th.

Heavy rain in Madras city (more than 30 cm in 3 days) inundated low lying areas and paralysed

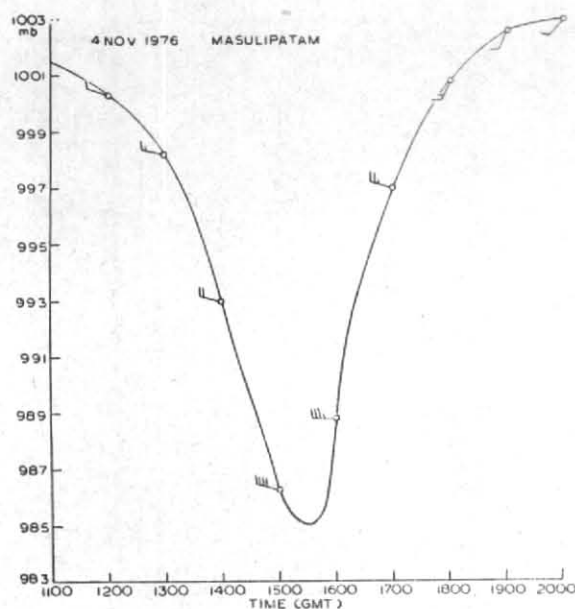


Fig. 8(a). Observations of wind (kt) and pressure (mb) at Masulipatnam on 4 November 1976

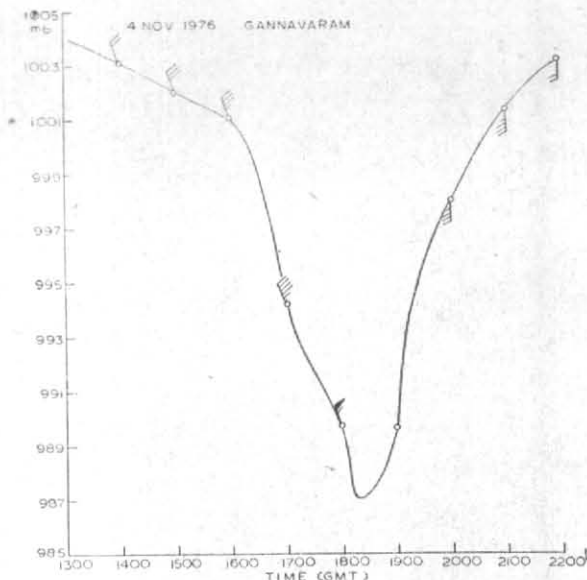


Fig. 8(b). Observation of wind (kt) and pressure (mb) at Gannavaram on 4 November 1976

the city life. About 50 villages in Nellore district were affected by floods resulting in damage to crops in that district. Road and rail communications in the coastal areas of north Tamil Nadu and south coastal Andhra Pradesh were disrupted due to breaches.

The satellite cloud pictures on 16th and 20th showed that this system had attained storm intensity on these days and could be classified under stage X, category 1 to 2 and on Dvorak's scale as T 3/3 and T 3.5/3.5 on 16th and 20th respectively. The satellite pictures from 17th to 19th showed considerable break up of organisation and indicated possibility of more than one centre in a broad band of northeast-southwest oriented cloud mass. Madras radar reported probable centre of circulation at some hours on 16th, 17th and 18th but no organised bands were seen in the radar at any time although the storm was within the radar range. The radar at Calcutta could not locate this storm.

Some of the significant features of the storm were :

(i) The upper air circulation associated with the storm showed a good southwestward slope with height and did not extend much above 300 mb. For instance, at 1200 GMT of 16th, when the storm was about 150 km to the east of Madras, the circulation at 500 mb level was over south Peninsula.

(ii) The radar at Madras did not show any cloud echoes typical of a storm with organised bands.

(iii) Simultaneously with this storm, there was a severe cyclonic storm in the Arabian Sea, moving westwards.

(6) Masulipatnam severe cyclone, 3-6 November

A low pressure area moving westwards from the Gulf of Siam across Andaman Sea concentrated into a depression on the morning of 3rd over central Bay with its centre near 13°N, 87°E. Thereafter moving in a northwesterly direction, the depression progressively intensified and became a severe cyclonic storm by the evening of 4th, as indicated by satellite picture when it was located about 50 km east of Masulipatnam. However, the low level winds over coastal Andhra Pradesh were only 20-25 kt strong that evening, suggesting that this system was a cyclone of narrow core (less than a degree in diameter). The cyclone crossed coast just north of Masulipatnam around 1500 GMT that night. As it was moving close to Masulipatnam and Gannavaram, these stations reported surface winds of speed 40 to 55 kt on 4th night. The lowest pressure of 985 mb was recorded at Masulipatnam at 1530 GMT and 987 mb at Gannavaram at 1810 GMT on 4th. The maximum pressure departure from normal at Masulipatnam was minus 22 mb. The hourly values of wind and sea level pressure at Masulipatnam and Gannavaram are represented diagrammatically in Figs. 8(a) and 8(b).

The severe cyclone weakened into a storm by 5th morning when it was centred about 75 km south-east of Hyderabad which reported a surface wind

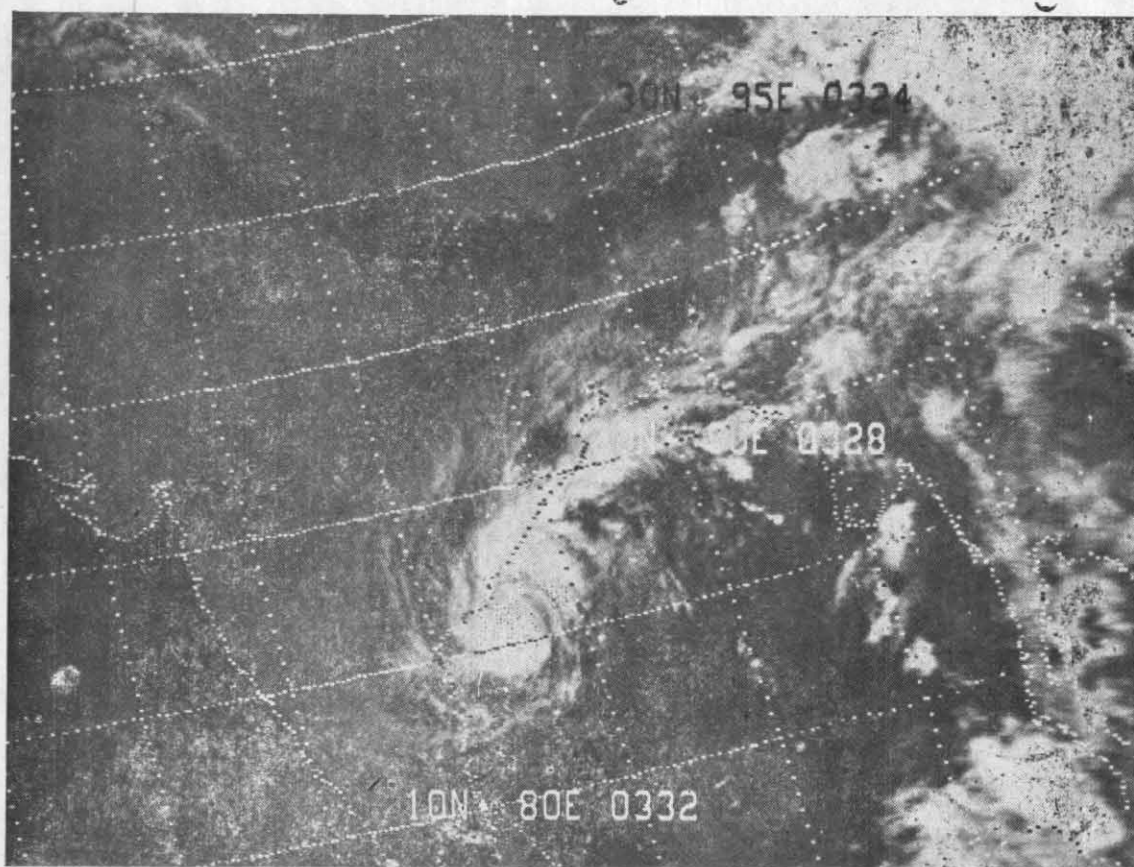


Fig. 9. Satellite view of Masulipatnam cyclone at about 0300 GMT on 4 November

of 35 kt from northeast at 0600 GMT. The satellite picture also showed, a clear 'eye' on that morning which indicated the severe intensity of the cyclone, but the available synoptic data did not confirm this intensity.

On 5th evening this system was still of storm intensity over north Interior Karnataka, with Bidar reporting a surface wind of 35 kt. The cyclone weakened into a depression by 5th night, moved westnorthwestwards across Maharashtra, emerged into the Arabian Sea off Bombay by 6th noon and dissipated that night. The drilling rig 'Sagar Samrat' of the Oil and Natural Gas Commission (position near 19°N, 72°E) reported surface wind SSE/18 kt at 1200 GMT of 6th.

In association with this cyclone, generally widespread rain or thundershowers occurred in coastal Andhra Pradesh on 5th and 6th and in Madhya Maharashtra, north Interior Karnataka and Telangana on 6th, with some very heavy falls on coastal Andhra Pradesh on 5th. According to press reports this cyclone claimed 18 human lives and damaged a large number of houses in Andhra Pradesh. Considerable damage to tobacco, cotton,

banana, sugarcane and paddy crops was reported from Krishna district. Many trees and electric poles were uprooted in Masulipatnam area. Masulipatnam port was reported to have suffered damage to the extent of about 1 lakh rupees. No tidal wave was reported in association with this cyclone.

Figs. 9 and 10 show the satellite view of this cyclone on 4th and 5th. But for the satellite pictures, it would not have been possible to detect and track this cyclone accurately. The system could be classified under stage X, category 3 with diameter about 2 degrees from the satellite pictures received at Bombay. This would give the maximum wind associated with this cyclone as 65 kt. For this maximum wind, the pressure at the centre of the cyclone would work out to be 987 mb, which agrees well with the lowest pressures reported by Masulipatnam and Gannavaram when the storm centre passed close to these two stations.

(7) *Kavali severe cyclone, 15-17 November*

A low pressure area from south China Sea which moved westwards across Andaman Sea on 14th, concentrated into a depression on the morning of 15th



Fig. 10. Satellite view (APT) of Masulipatnam cyclone at about 0400 GMT on 5 November with eye visible



Fig. 11. Satellite view (APT) of Kavali cyclone at about 0300 GMT on 16 November

with its centre near 10.5°N , 87°E . Moving rather fast in a northwesterly direction, it became deep the same evening and rapidly intensified into a severe cyclonic storm on the morning of 16th when it was centred near 13.8°N , 82.5°E . Ship *VWLG* reported northerly wind near 12°N , 84°E at 1100 GMT on 15th and southsouthwesterly wind near the same position at 1330 GMT the same day and the pressure fell during this period from 1002.2 to 996.2 mb. The wind shift and the fall of pressure suggested that the depression centre passed close to this ship that evening. Another ship *UYJE* near 12.5°N , 87.0°E reported a wind of 30 kt at 1200 GMT of 15th.

The satellite pictures on 16th morning and evening showed that the depression had intensified into a severe cyclonic storm. The system was classified under stage X, category 2 (and T4 in Dvorak scale) corresponding to a maximum wind of 60 kt. The satellite picture of this storm on 16th is reproduced in Fig. 11. This storm was tracked by the cyclone warning radar at Madras from 0200 GMT to 1800 GMT on 16th. The radar track is reproduced in Fig. 12. The radar showed the 'eye' of the storm (on 16th morning and evening). Figs. 13 and 14 show the radar view of this storm on 16th. Ship *UYJE* near 16.5°N , 83.5°E reported surface wind E/38 kt at 0600 GMT and ship *ATJW* near 15°N , 82°E reported ESE/30 kt at 1500 GMT on 16th.

The severe cyclonic storm crossed south Andhra coast between Nellore and Kavali (Kavali is

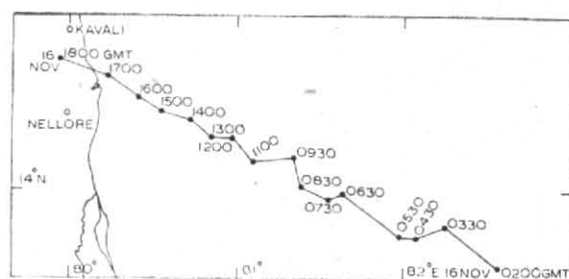


Fig. 12. Radar track of severe cyclonic storm, 16 November

about 35 km north of Nellore) around mid-night of 16th and weakened into a low over Rayalaseema and adjoining south Interior Karnataka by 17th evening. Widespread rain occurred in coastal Andhra Pradesh on 17th and 18th with isolated heavy to very heavy falls in south coastal Andhra Pradesh.

According to press reports as well as the report of the officer who toured the cyclone affected areas, this cyclone claimed about 30 lives and caused considerable damage to tobacco, betel vine, banana and mango gardens in Kavali and Kovur taluks of Nellore district. Electric and telephone poles were bent and trees were uprooted and about 10,000 houses were damaged. Minor damage also occurred in Nellore and Atmakur taluks. Tiles and asbestos roofs were blown off at many places between Nellore and Kavali. The total damage was estimated to be of the order of 3 crores of rupees.



Fig. 13. Picture of Kavali cyclone at 0428 GMT on 16 November taken by Cyclone Warning Radar at Madras



Fig. 14. Picture of Kavali cyclone at 1223 GMT on 16 November taken by Cyclone Warning Radar at Madras

Although the severe cyclone passed within 30 km of Nellore observatory, the wind at Nellore did not exceed 20 kt. This would suggest that the strongest winds did not extend beyond 20 km or so from the storm centre. This was also supported by the report of the touring officer according to which severe damage extended to only about 20 km to the north and 15 km to the south of the track. The maximum wind associated with this cyclone was also estimated as 60 kt as per the report of the touring officer. This would give the pressure at the centre of the storm as 992 mb.

(8) Cyclonic storm, 22-29 November

A low pressure area which lay over south Andaman Sea on 21st moved westwards and concentrated into a depression on the evening of 22nd over southeast Bay with its centre near 8.0°N , 90.5°E . Ship *ATJJ* near 9.5°N , 92.0°E reported easterly wind of 25 kt at 1200 GMT that day. The depression became deep on the morning of 23rd, as indicated by many ships' reports in the depression field. Moving initially westnorthwest and later in a northwesterly direction, the deep depression lay about 75 km northeast of Madras on the morning of 25th. The radar picture of Madras on that morning showed a circulation centre near 13.3°N , 80.7°E . Madras recorded a pressure departure of *minus* 10 mb on this morning.

The depression skirted south Andhra coast upto 27th and then, as it came in the region of upper westerly flow north of the sub-tropical ridge line, moved away northeastwards to Arakan coast by 30th morning and weakened. This depression appears to have attained the intensity of a cyclonic storm on the morning of 27th for a short time when it was centred about 100 km south of Kakinada, as indicated by better organisation in satellite cloud picture and low level winds of 35/40 kt at Gannavaram on that morning.

In association with this system Madras city (Nungambakkam) and Madras Airport (Meenam-bakkam) had an all time record rainfall of 45 cm and 35 cm respectively on 25th. Generally widespread rain occurred in Bay Islands from 22nd to 24th with some heavy to very heavy falls on 22nd and 23rd. Car Nicobar recorded 24 cm, Nancowry 16 cm and Kondul 11 cm on 22nd and Kondul 20 cm on 23rd. Fairly widespread rain with heavy to very heavy falls also occurred in north Tamil Nadu, coastal Andhra Pradesh and and Rayalaseema between 25th and 27th.

According to press reports, the unprecedented and torrential rain that lashed Madras city and adjoining areas flooded the city affecting about 3 lakh people, particularly in the slum areas. Many houses collapsed in Madras city. Train services in the Madras-Gudur-Renigunta sections were

dislocated. There was extensive damage to roads and telecommunication systems. About 50 persons lost their lives due to house collapses and electrocution. Very heavy rain in Nellore district caused floods in the *Kalindi* and *Suvarnakh* rivers leading to damage to a large number of houses. The death toll was about 45. Crops in Nellore, Guntur, Krishna, Chittoor, Cuddapah and East Godavari districts were damaged. Due to the three successive storms which affected Andhra Pradesh in November, the total damage was estimated to be over Rs. 200 crores. About 160 persons were reported killed and 2 lakh houses were damaged. Paddy in 16 lakh acres and other crops in 4.5 lakh acres were severely affected.

The recurvature of the cyclonic storm occurred under the influence of a westerly trough moving across north India. There were a few similarities between this storm and the earlier one of 15 October to 21 October which also recurved — (i) in their tracks, (ii) satellite cloud patterns after recurvature and (iii) 500 mb flow pattern on the day of recurvature. This system also showed a southwesterly slope with height.

(9) *Severe cyclonic storm, 28 December 1976-3 January 1977*

A trough of low which was over south Andaman Sea on 24th and 25th moved westwards slowly to southeast Bay by 27th and concentrated into a depression on the evening of 28th with its centre near 7.5°N , 89.0°E . Ship *JGGP* near 6°N , 87°E reported NW/18 kt at 1200 GMT of 28th. The satellite picture on the same evening showed that this system had reached "stage B". Moving in a northeasterly direction, the depression intensified into a cyclonic storm by the evening of 29th and into a severe cyclonic storm on 30th evening when it was centred near 10°N , 92°E . Ship *ATQV* near 9°N , 93°E reported SE/SSE wind of 37 kt at 1100 GMT of 30th. Satellite classification of this system was T 4/4 in Dvorak's scale on 30th evening which indicates the maximum wind associated with this storm as 60 kt.

The storm continued to move northeast and developed a core of hurricane winds on the 31st. The satellite picture showed an 'eye' on that day. The APT picture received at Bombay showed the system in stage X, category 3 with diameter 2 to 3 degrees, which gives the maximum wind as 70 kt. Washington estimated the max. wind as 80 kt (T 5/5 on Dvorak's scale). The satellite view of this cyclone on the morning of 31st is reproduced in Fig. 15.



Fig. 15. Satellite view of Bay cyclone showing clear eye at about 0300 GMT on 31 December

The cyclone passed within 50 km to the east of Port Blair on 31st. The observatory at Port Blair recorded a maximum wind of 52 kt in gust at 0730 GMT on 31st and the lowest pressure of 993 mb at about the same time. The Naval Met. Office at Port Blair recorded a maximum wind of 60 kt and lowest pressure of 994 mb that day. The Naval ship *INS Sakti* anchored at Port Blair recorded a maximum wind of 75 kt and lowest pressure of 989 mb at 0730 GMT on 31st. The radar on board this ship showed the eye of the storm near 11.6°N , 93.2°E at about 0800 GMT on 31st.

The severe cyclonic storm weakened into a cyclonic storm on the morning of 1 January and lay about 150 km to the northeast of Port Blair. It weakened further into a depression by 1st night and moved westwards and dissipated by the evening of 3rd about 200 km to the northwest of Port Blair. A satellite picture of this storm in the weakening phase on 2 January is shown in Fig. 16.

In association with this system rainfall was generally widespread in Bay islands from 27 December to 2 January with some very heavy falls on 30th and 31st. Port Blair and Long Island recorded 37 cm and 82 cm of rain respectively on 31 December which are records for these stations. According to reports, strong winds and very heavy rain caused widespread damage in Little Andaman and south Andaman, particularly in Neil and Havelock Islands. A large number of trees were uprooted and roofs of houses blown off in these areas. Considerable damage to fruit orchards,



Fig. 16. Satellite view (APT) of Bay cyclone on the morning of 2 January 1977 in its weakening phase

vegetable gardens and crops in the fields was reported. A few lives were also lost.

2.2. Arabian Sea

(1) Mahuva cyclone, 29 May-5 June

This storm developed in the leading edge of the advancing monsoon current.

A low pressure area formed to the west of Lakshadweep on the morning of 29 May and concentrated into a depression on that evening with its centre near 12°N , 70°E . Moving in a northeasterly direction, the depression intensified into a cyclonic storm by 31st morning when it was centred near 14.5°N , 71.5°E . The storm became severe around noon that day. Ships *PJLP* and *VWXN* within 100 km of storm centre reported 50 kt at 0600 GMT on 31st. Moving practically in a northerly direction, it crossed into Saurashtra near Gopnath Point (between Mahuva and Bhavnagar) on the morning of 3 June and again Gujarat coast near Port Cambay on the morning of 4th and weakened gradually into allow over southeast Rajasthan and adjoining parts of west Madhya Pradesh and Gujarat region by 6th. This storm had a core of hurricane winds on 2nd as evidenced by the observations recorded by the ships of ONGC located 100 to 200 km west of Bombay.

In association with this system the southwest monsoon advanced into Comorin-Maldives area on 30 May and into Kerala on 31st. The monsoon advanced rapidly further north and covered Karnataka, Maharashtra and Gujarat States, west Madhya

Pradesh and southeast Rajasthan by 7 June. The monsoon was active or vigorous in Gujarat State, Konkan and Madhya Maharashtra between 4th and 7th and in west Madhya Pradesh on 7th. A few heavy falls were reported from Lakshadweep and coastal Karnataka on 1 June. Heavy to very heavy rain occurred in Konkan from 1st to 5th, in Madhya Maharashtra from 3rd to 7th, in Gujarat State from 4th to 7th and in west Madhya Pradesh on 7th.

About 70 persons were reported to have lost their lives in Gujarat State and loss to property including houses and crops was estimated at Rs. 3 crores. Nearly 4500 heads of cattle perished. About 2500 villages in nine districts of Gujarat were affected, the worst affected being Bhavnagar, Kaira, Broach and Baroda. Uprooting of trees, electric and telephone poles were reported from some of the above districts. 17 fishermen from Bombay lost their lives and some parts of western Maharashtra were affected by floods due to heavy rain.

The lowest pressure reported by a land station close to the storm centre was 983.4 mb at Bhavnagar at 1530 GMT on 3 June, which gives the pressure departure from normal as about *minus* 19 mb. The hourly values of wind and pressure at Bhavnagar on 3 June are depicted in Fig. 17. The eye of the storm passed between the two ONGC ships, *Sagar Samrat* (19.3°N , 71.9°E) and *Shenon Dahay* (19.5°N , 71.3°E) on the evening of 2 June and close to *Hakon Magnus* (another ONGC ship at 18.6°N , 71.0°E) on the morning of 2 June. *Shenon Dahay* reported the lowest pressure of 981 mb at 1230 GMT on 2nd. The strongest wind of 90 kt (110 kt in gust) and swells of 10 to 15 metres were reported by *Hakon Magnus* on 2nd morning. *Shenon Dahay* reported 60 to 80 kt wind and *Sagar Samrat* 50 to 60 kt on 2nd. *Shenon Dahay* reported swells 6m high on the same day.

The storm was tracked by the cyclone warning radar at Bombay from 0400 GMT of 1 June to 2300 GMT of 2nd. The radar track of this storm is given in Fig. 18.

The satellite picture of the storm showed an 'eye' on the morning of 2nd, which is reproduced in Fig. 19. The maximum wind speed that could be estimated from the satellite pictures of this storm was 70 kt.

(2) Cyclonic storm, 27 August-8 September

A low moved from northwest and adjoining west central Bay across Orissa to southeast Madhya Pradesh on 27 August and concentrated into a depression that morning with its centre 100 km southeast of Raipur. Moving westnorthwest upto

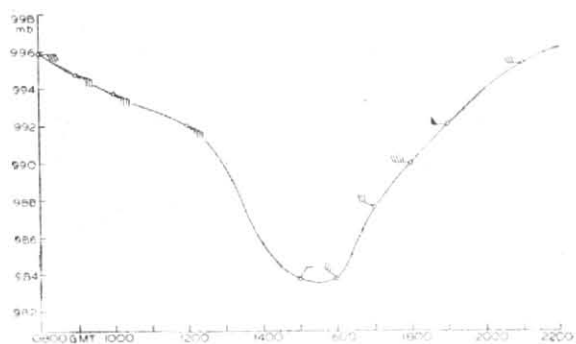


Fig. 17. Observations of wind (kt) and pressure (mb) at Bhavnagar on 3 June 1976

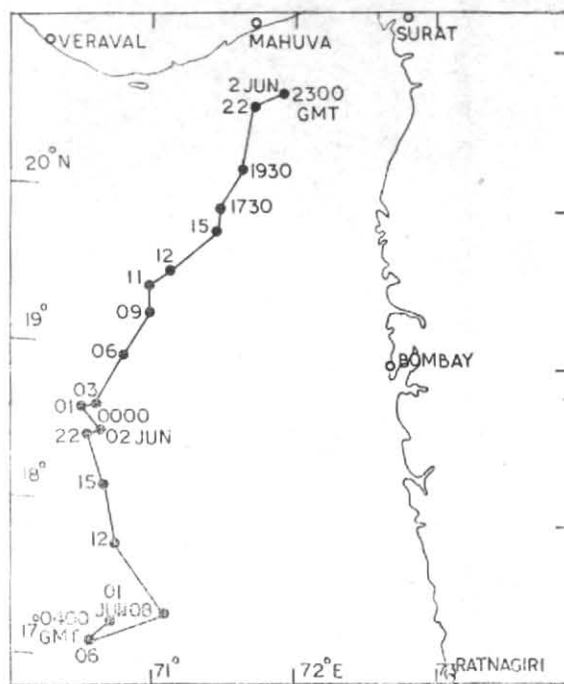


Fig. 18. Radar track of severe cyclonic storm, 1-2 June 1976

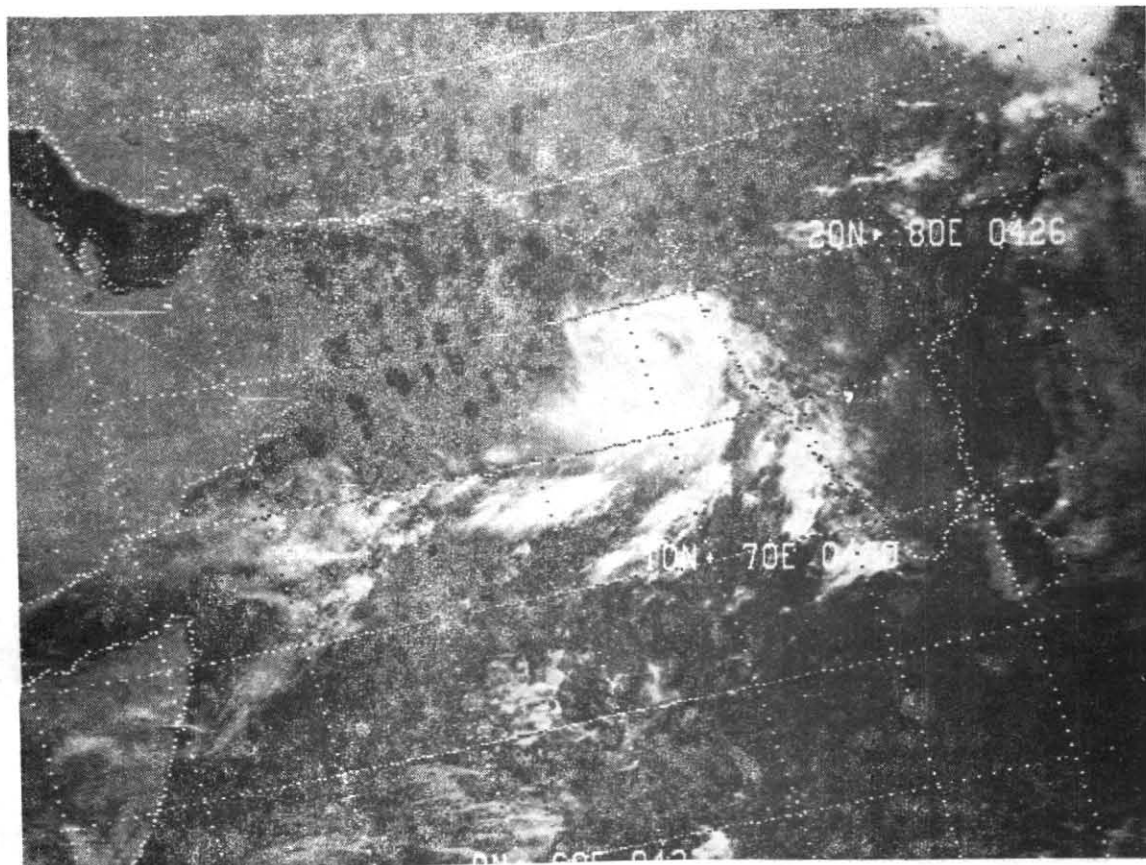


Fig. 19. Satellite view of Mahuva cyclone at about 0430 GMT on 2 June showing the eye of the cyclone

29th and later westwards, the depression intensified into a cyclonic storm on the morning of 31st with its centre close to Naliya, as it was emerging into northeast Arabian Sea. Okha reported surface wind westerly 45 kt on 31st morning. The storm weakened into a depression by the evening of 1 September. Subsequently it made a loop in its track and also reintensified into a cyclonic storm on the morning of 5th about 100 km west of Veraval. Veraval reported southerly winds of 40 kt at 0.3 km and 0.6 km a.s.l. on the morning of 5th and Jammagar 50 to 55 kt at these levels on the evening of 5th. The storm weakened again into a depression over northeast Arabian Sea by the evening of 6th. Subsequently it moved in a westerly direction and dissipated close to Oman coast. Available data do not yield any clue to the unusual track of the system over northeast Arabian Sea.

The pressure departure from normal near the centre of this system was *minus* 8 to 9 mb on 29th and 30th and *minus* 12 mb on 31st. Naliya reported the lowest pressure of 990.4 mb at 1200 GMT on 31st.

The satellite picture of this system when it had intensified into a cyclonic storm on the morning of 31 August is given in Fig. 20.

As this system moved across Madhya Pradesh and Gujarat State between 27 and 31 August, there was a good spell of rainfall over the central parts of the country from Orissa and Gangetic West Bengal to Gujarat State. Ahmedabad reported 25 cm of rain on 30 August which is a record for that station for August. Heavy rain and flood disrupted road and rail communications in many parts of Gujarat. No heavy rain or damage was caused by this system when it was a cyclonic storm over northeast Arabian Sea in the first week of September.

(3) Severe cyclonic storm, 12-18 October

A low pressure area moved westnorthwestwards from Comorin-Maldives area to southeast Arabian Sea between 8th and 12th and concentrated into a depression on the evening of 12th with its centre near 11°N, 70°E. Moving practically westwards, the depression intensified into a cyclonic storm on 14th evening when it was centred near 12°N, 63°E. Continuing to move westwards, the storm became probably severe by 15th evening as indicated by satellite picture which showed the system in stage X, Cat-2, diameter to 2-3 degrees which would indicate the maximum wind speed as 50 to 60 kt. The storm later weakened into a depression on 17th near Socotra and dissipated by 19th to the west of Socotra.

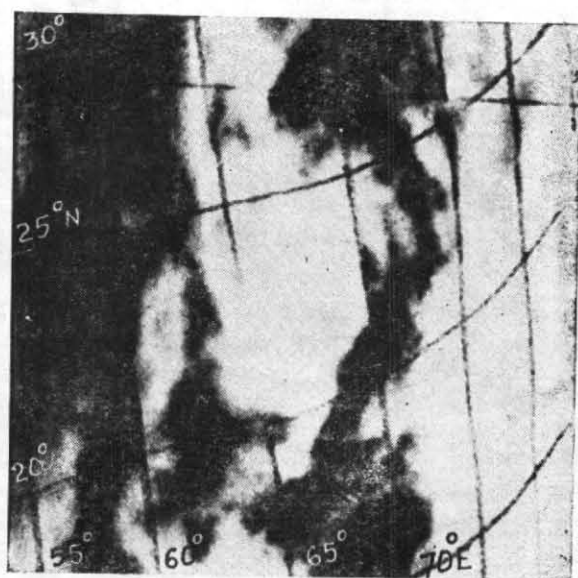


Fig. 20. Satellite picture (APT) of Arabian Sea cyclone at about 0430 GMT on 31 August

During the formative stage when it moved as a low pressure area from Comorin to southeast Arabian Sea between 8th and 12th, the system caused generally widespread rain with a few heavy to very heavy falls in Kerala and Lakshadweep from 10th to 12th. Subsequently it did not affect the weather over country, as it was moving away westwards.

This system was tracked mainly with the help of satellite cloud pictures. Fig. 21 shows the satellite cloud picture of the storm at its peak intensity on the morning of 16th. Fig. 22 shows the storm weakening into a depression on 17th morning.

(4) Deep depression, 13-16 November

A low pressure area which lay over Lakshadweep on 12 November moved westnorthwest and concentrated into a depression by the evening of 13th over southeast Arabian Sea with its centre near 12°N, 65°E. Ship *GYHB* near 13°N, 89°E reported southeasterly wind of 18 kt at 1200 GMT of that day and rain at the time of observation. Satellite pictures showed organised cloud mass between 10°N and 15°N around 65°E on the night of 13th. Continuing to move in a westnorthwesterly direction, the depression weakened into a low by the evening of 16th over west central Arabian Sea.

A few ships in the field of this depression reported winds of speed 17 to 25 kt. Satellite pictures from 14th to 16th morning showed organisation in the cloud field similar to stage C. These suggested

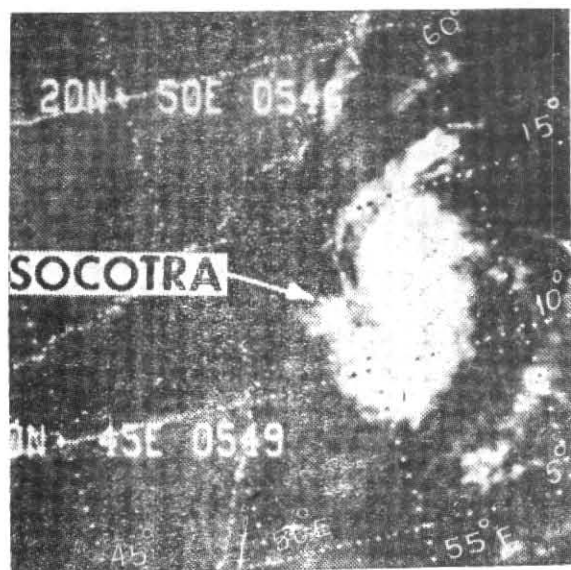


Fig. 21. Satellite view of Arabian Sea cyclone at about 0600 GMT on 16 October

that the system was a deep depression from 14th to 16th.

This system did not affect the weather over India.

2.3. Land depression

Deep depression, 28 July-1 August

A low pressure area developed over north Bay and adjoining land on the morning of 26 July. It moved into Bangla Desh and adjoining Gangetic West Bengal by 27th evening and concentrated into a deep depression on the morning of 28th with its centre about 50 km northeast of Calcutta. Moving in a westnorthwesterly direction upto central Rajasthan by 31st, the depression moved northwards under the influence of a westerly trough moving across Jammu & Kashmir and weakened



Fig. 22. Satellite picture (APT) of Arabian Sea cyclone at about 0600 GMT on 17 October in its weakening phase

into a low over north Pakistan by the evening of 1 August.

The easterlies upto about 1 km a.s.l. to the north of this depression within 200 to 300 km from the centre were generally 30 to 40 kt strong on most days, while the westerlies to the south in the depression field were relatively weaker, which is an interesting feature of this depression. The pressure departure near the centre of the depression was minus 7 to 9 mb.

In association with this system, fairly widespread rain with heavy/very heavy falls occurred in Gangetic West Bengal and Orissa on 23th, in Bihar Plateau on 29th, in Madhya Pradesh from 29 July to 1 August, in Rajasthan and Punjab on 31 July and 1 August and in Jammu & Kashmir on 1 and 2 August. Floods affected Jammu & Kashmir, particularly, Anantnag and Srinagar districts and many parts of Punjab causing damage to crops, houses and roads.

Note: (1) Figs. 2, 15 and 21 have been reproduced from Annual Typhoon Report 1976, JTWC, Guam.
 (2) Fig. 3 has been reproduced from NOAA Environmental Satellite Imagery, Washington.
 (3) Figs. 7, 9 and 19 were obtained from Washington.