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Cyclones and depressions over the Indian seas and the Indian sub-continent during 1987

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1. Chief features

During the year 1987 five cyclonic storms developed over the Bay of Bengal. Of those five storms, the first one formed in the winter season and the second one in the beginning of the monsoon season. The last three developed during the post monsoon season. The first storm attained hurricane intensity and two of the post monsoon storms intensified into severe ones. Besides these storms, three depressions developed over the land areas of India and Bangladesh during the monsoon season and a deep depression over the Bay of Bengal in the post monsoon season. The first monsoon depression developed in the last week of August which was very late. Of these nine intense systems, the winter hurricane and the post monsoon deep depression dissipated over the sea.

The cyclogenic activity over the Arabian Sea was quite low during this year and no intense system formed over the sea during the year 1987.

The tracks of the storms and the depressions have been shown in Fig. 1. Table 1 shows the details of these storms and depressions and Table 2 shows the frequency of monthly occurrence of these systems. The systems have been individually discussed under Sections 2 & 3.

2. Bay of Bengal

2.1. *Severe cyclonic storm with core of hurricane winds, 30 January to 4 February*

Climatologically the formation of a storm in the Indian seas during the month of January is rare. During the last 110 years (1877-1986), 5 storms formed in the month of January and all of them in the Bay of Bengal.

The system developed over southeast Bay and adjoining north Indian Ocean and became a depression on 30th. Initially it moved in a northwesterly direction but from 1st onwards it took a northnortheasterly course and dissipated over northeast Bay off Bangladesh coast by midnight of 4th.

Relevant ship observations of this system are given in Tables 3 and 4. The system could be detected as a depression with the help of INSAT imagery of 30th morning. It lay at 0300 UTC of 30th centred near Lat. 5.5° N, Long. 88.5° E. Moving in a northwesterly direction it intensified into a deep depression on 31st morning centred near Lat. 7.0° N, Long. 87.0° E. Satellite classification of the system was T 2.5 at 0300 UTC of 31st. Also the observation of ship HSAT indicated the strengthening of northeast trades over southeast Bay. INSAT imagery of 0600 UTC indicated further intensification of the system. On the basis of the 0600 UTC imagery the system was classified as T 3.0. At 1200 UTC of 31st the cyclonic storm lay centred near Lat. 7.5° N, Long. 86.0° E.

However, the system further intensified into a severe cyclonic storm (S.C.S.) and lay centred at 0300 UTC of 1st near Lat. 8.0° N, Long. 85.5° E. The winds in the left hand quadrant of the system strengthened as was evident from the observation of the ship 3FQEZ. Satellite classification was T 3.5 at 2100 UTC of 31st, and also at 0300 UTC of 1st, but it increased to T 4.0 at 0600 UTC (Fig. 4). The storm started recurving from 1st morning and moving faster, at 1200 UTC of 1st, it lay centred near Lat. 10.0° N, Long. 86.0° E as a S.C.S. with a core of hurricane winds (CHW). Continuing it's northnortheastward course the S.C.S. (CHW) lay at 0300 UTC of 2nd centred near Lat. 13.0° N, Long. 87.5° E. The satellite classification at this hour continued to be T 4.0. The observation of ship 8QME (*Pioneer Elegant*), given in Table 4, showed that the wind in association with the system was 70 to 80 kt or more. The ship came in the inner core region of the storm and it recorded lowest pressure of 975 hPa and wind speed of 70-80 kt from the south/southwesterly direction at 0900 UTC of 2nd. Though the ship's course was southeasterly/02 kt or so, it was drifted northwards between 0900 and 1200 UTC of this day. At 1200 UTC of 2nd when the S.C.S. (CHW) lay centred at Lat. 14.5° N, Long. 88.5° E the ship continued to report strong westerly wind.

TABLE 1

Details of depressions/cyclones over Indian seas and neighbourhood in 1987

Type of system	Life period	Point of crossing the coast with date	Lowest pressure recorded/central pressure (hPa)	Maximum wind speed recorded	Highest T. No. attained
		Originated over Bay of Bengal			
(1) Severe cyclonic storm with core of hurricane winds	30 Jan-4 Feb	Dissipated over northeast Bay	975 hPa at 0900 UTC of 2nd by ship 8QME	South to southwesterly/70 to 80 kt at 0900 UTC of 2nd by ship 8QME	4.0
(2) Bangla Desh cyclonic storm	1-5 Jun	Crossed Bangladesh coast near Dakhin Shahbazpur in the midnight of 4th	Agartala 986.8 hPa at 0300 UTC of 5th	Ship DIGC 310°/35 kt at 0000 UTC of 3rd	3.0
(3) Ongole cyclonic storm	14-19 Oct	Crossed south Andhra coast just north of Ongole between 01 and 02 UTC of 16th	Ongole 995.1 hPa at 0200 UTC of 16th	Ship ATBF 360°/34 kt at 0600 UTC of 15th	3.0
(4) Nellore severe cyclonic storm	31 Oct-3 Nov	South Andhra coast just north of Nellore on 3rd morning	Nellore 984.3 hPa at 2300 UTC of 2nd	Ship ATKJ wind 140°/50 kt at 0000 UTC of 2nd	3.5
(5) Machilipatnam severe cyclonic storm	11-13 Nov	South Andhra coast south of Machilipatnam around 01 UTC of 13th	Machilipatnam 994.0 hPa at 2300 UTC of 12th and 0000 UTC of 13th	Ship VTBN 300°/41 kt at 1200 UTC of 12th	3.5
(6) Deep depression	19-22 Dec	Dissipated over the sea	—	020°/46 kt by ship VWNS at 0300 UTC of 21st	2.0
		Originated over land			
(1) Depression	26-29 Aug	—	Sidhi 991.6 hPa at 1200 UTC of 28th	Dhaka, SSE/20 kt Ranchi, SE/20 kt	—
(2) Do.	11-12 Sep	—	Hazaribagh 993.6 hPa at 1200 UTC of 12th	—	—
(3) Do.	15-16 Sep	—	Umaria 998.1 hPa at 1200 UTC of 15th		

TABLE 2

Monthly occurrence of different type of systems during 1987

System	Jan	Feb-May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
				Bay of Bengal						
Depression	—	—	—	—	—	—	—	—	1	1
Cyclonic storm		—	1	—	—	—	1	—	—	2
Severe cyclonic storm	—	—	—	—	—	—	1	1	—	2
Severe cyclonic storm with core of hurricane wind	1	—	—	—	—	—	—	—	—	1
				Arabian Sea						
				Nil						
				Land						
Depression	—	—	—	—	1	2	—	—	—	3
Total	1	*Nil*	1	—	1	2	2	1	1	9

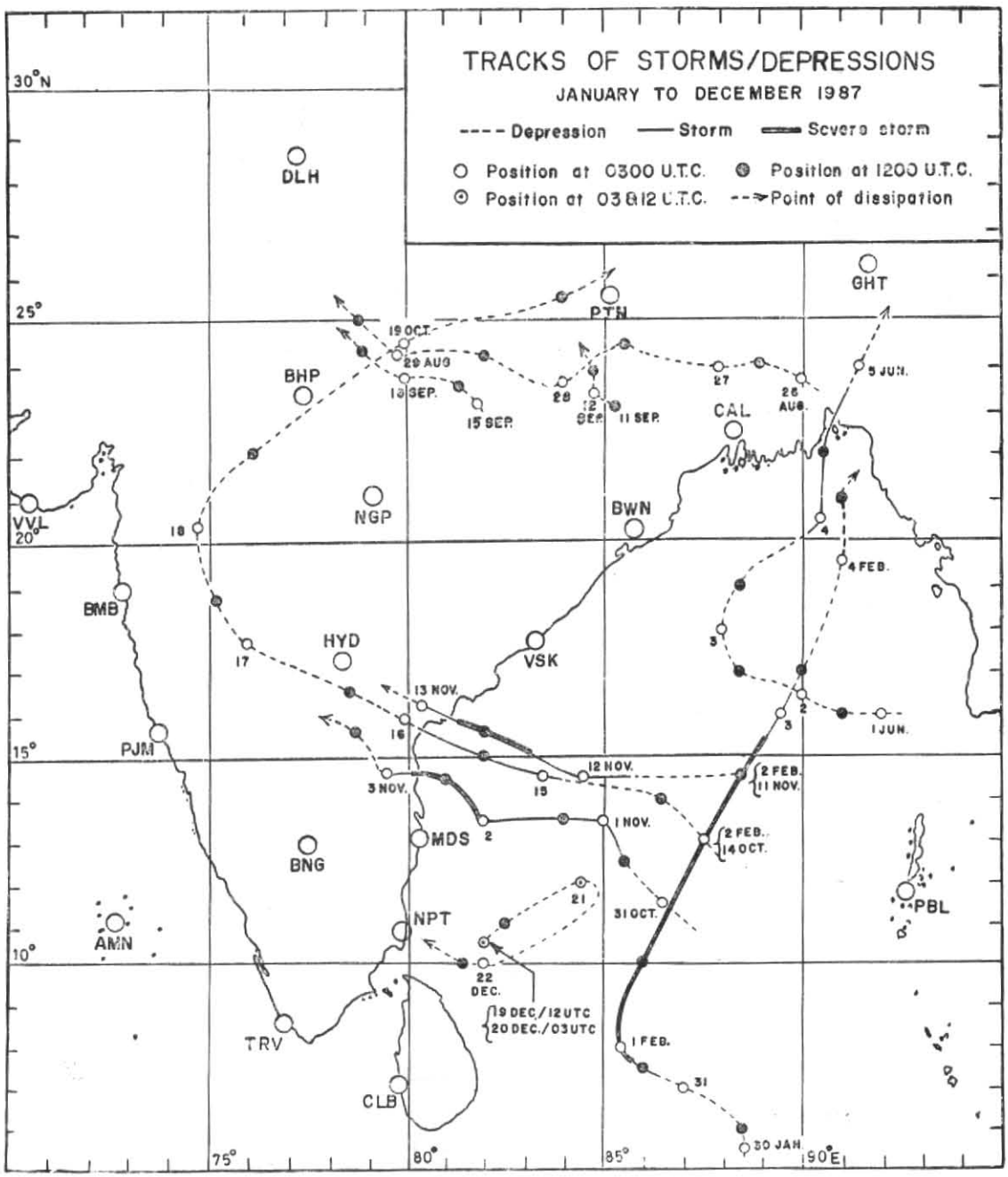


Fig. 1. Tracks of storms/depressions during January-December 1987

On the basis of 0000 UTC INSAT imagery of 3rd the system could be classified as T 3.0 and that on the basis of 0300 UTC as T 2.5. Ship observations also indicated the weakening of the system to a cyclonic storm. At 0300 UTC of this day the storm lay centred near Lat. 16.0°N, Long. 89.5°E. By 1200 UTC of 3rd the storm further weakened into a deep depression and lay centred around Lat. 17.0°N, Long. 89.5°E. At this hour the T-classification on the basis of INSAT imagery was 2.0. Also the circulation of the system showed considerable tilt with height.

By 4th morning, it moved further northwards and weakened into a depression over northeast Bay centred near Lat. 19.5°N, Long. 90.5°E. On the basis of 0300 UTC INSAT picture it could be classified T 1.5 but was assigned C.I. No. 2.0. At this hour Akyab reported pressure 1014.6 hPa and wind SE/10 kt. The system continued to be a depression at 1200 UTC of 4th but by 1500 UTC it further weakened over northeast Bay off Bangladesh coast. The remnant of the system became unimportant over Nagaland, Manipur, Mizoram & Tripura and neighbourhood by next day.

The areal extent of the storm was quite large. The diameter of the highest closed isobar (H.C.I.) was about 8 to 10 degrees on 1st and 2nd, and reduced to 5 to 6 degrees on 3rd. The intensification of the system took place, while it was drifting in the mid and upper tropospheric southeasterly current. It started weakening

TABLE 3

Relevant ship observations in Bay of Bengal during 31 Jan to 4 Feb 1987

Call sign of the ship	Time of obsn. (UTC)	Position		Wind		Special remarks
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
		31 January 1987				
ELFQ	0600	5.8	87.6	200	14	
4PKC	Do.	5.8	90.0	180	19	SST 28.0 °C
HSAT	Do.	10.5	88.0	050	30	
YTMD	1200	5.7	86.2	230	15	SST 29.0 °C
3 FQEZ	Do.	5.5	87.5	220	18	SST 29.0 °C
USBQ	Do.	5.8	88.9	170	18	
HSAT	Do.	9.6	87.2	050	30	
		1 February 1987				
3FQEZ	0000	5.5	85.2	270	48	SST 29.0 °C
HSAT	Do.	8.6	89.8	120	30	
VTKT	Do.	9.9	83.1	020	22	
VTKT	1200	12.3	83.8	020	30	
		2 February 1987				
VWTL	1800	14.8	84.4	040	18	
		3 February 1987				
VTKK	0000	15.8	85.4	040	24	
ATGH	Do.	17.4	90.7	090	26	
8QME	Do.	13.1	89.1	200	20	
ATGH	0300	16.1	91.6	140	25	
ATGH	0900	15.5	91.7	160	25	
ATKD	1200	17.8	85.1	010	26	
		4 February 1987				
Sandheads	0300	—	—	040	15	
ATJX	Do.	18.4	88.5	050	18	

TABLE 4

Observations of ship 8QME (*Pioneer Elegant*) on 2 February 1987

Time of obsn. (UTC)	Position		Pressure (hPa)	Wind	
	Lat. (°N)	Long. (°E)		Dir.	Speed
0000	—	—	1008.0	—	—
0400	—	—	1005.8	—	—
0600	—	—	997.5	—	—
0800	—	—	980.0	—	—
0900	13.9	88.1	975.0	S/SW'y	70-80 kt
1000	—	—	987.0	—	—
1130	14.0	88.1	990.0	W	65 kt
1200	—	—	1001.0	—	—
1800	—	—	1010.0	—	—

when it came under the influence of westerly current and dissipated in the region of strong mid and upper tropospheric westerly field. The system moved along the periphery of the mid and upper tropospheric anticyclone over southeast Asia and adjoining south China Sea.

2.2. *Bangladesh cyclonic storm*, 1-5 *June*

The system formed on the leading edge of the monsoon current over east central Bay on 1st. Initially it moved to west to westnorthwestwards till 2nd evening and then northwards upto 3rd evening. Thereafter, it recurved and crossed Bangladesh coast near Dakhin Shahbazpur in the midnight of 4 June.

Relevant ship observations with respect to the system are given in Table 5. Observations from the ship 9MWK and VWDG on 1st indicated the formation of a depression over east central Bay which lay at 0300 UTC of the day centred near Lat. 16.0°N, Long. 92.0°E

TABLE 5

Ship observation from 1 to 4 June 1987

Call sign of the ship	Hr. of obsn. (UTC)	Position		Wind		Special remarks
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
		1 June				
9MWK	0000	15.6	92.2	270	19	Raining
9MWK	0600	16.5	91.5	100	22	Overcast sky
VWDG	0600	16.9	91.0	030	20	Overcast sky
		2 June				
ATIR	0000	11.7	89.9	210	20	
VWDG	0300	14.3	92.8	180	24	SST 31.0°C
		3 June				
VTKK	0000	15.4	82.3	210	25	Light rain
ATGE	0000	15.3	82.7	220	10	Do.
VTFY	0600	11.8	84.2	330	30	Raining
VTKK	1200	17.9	84.6	230	16	Overcast sky
		4 June				
DIGC	0000	19.8	90.4	310	35	Raining
ATIQ	0000	19.6	86.3	300	07	
VTFY	0000	15.8	83.9	220	20	
DIGC	0300	19.2	89.4	240	20	Shower

On the basis of the satellite (INSAT-1B) imagery the system could be classified as T 1.5 at this hour. The depression took a westerly course till the evening of 2nd without further intensification. The systems moved northwards and the Bay branch of the monsoon current also moved northward in association with the system. Satellite observation indicated no significant intensification after 2nd morning and by 0600 UTC of the day the system was classified as T 2.0. From the ship observations (Table 5) between 1 & 4 June indicated moderate to strong monsoon current over southeast and adjoining east central Bay. The system intensified into a deep depression centred at 0300 UTC near Lat 18.0°N & Long. 88.0 °E on 3rd morning. At this hour Cyclone Detection Radar (CDR), Paradip could locate the system with the help of spiral bandings. Also the system was classified as T 2.5 with the help of INSAT imagery. However, the winds at 0.9 km a.s.l. in the coastal belts of Orissa and Gangetic West Bengal were rather weak (5 to 10 kt) in the morning of 3rd. However, from the observations of ship VTKK and ATGE, it was evident that the rainfall belt in the southwest sector of the depression centre extended to a distance of about 750 km. System slowed down after 3rd morning as it was recurving to the north. 1200 UTC observations of 3rd from south Orissa coast indicated that these areas were outside the circulation field of the system. At this hour surface wind at Paradip was E/15 kt and at Puri and Gopalpur were SE/05 kt. Satellite imageries from 0900 UTC also indicated slight weakening of the system. The system could be classified, on the basis of INSAT imageries, as T 2.0 at 0900 and 1200 UTC of 3rd. After 3rd morning, it recurved northeastwards and headed for Bangladesh coast. In the morning of 4th ship DIGC reported winds of 35 kt at 0000 UTC and 20 kt at 0300 UTC. From these observations of the ship, it appeared that the system further intensified into a cyclonic storm centred at 0300 UTC on 4th near 20.5°N & 90.5° E. At 1200 UTC of 4th coastal winds of Bangladesh strengthened. Chittagong and Cox Bazar reported 130°/32 kt and 130°/13 kt respectively. Sandheads wind at this hour was NNE/15 kt and the satellite classification was T 3.0. Incidentally 32 kt wind at Chittagong was the highest speed recorded over land. All these observations indicated the small core of the storm. At 1800 UTC of 4th, Chittagong and Dhaka reported surface winds 140°/26 kt and NE/15 kt respectively. These observations indicated that at this hour the storm was crossing Bangladesh coast near Dakhin Shahbazpur. Moving northnortheastwards the storm weakened into a deep depression and at 0300 UTC of 5th lay centred near Agartala, which reported surface wind 360°/03 kt. Agartala also recorded mean sea level pressure of 986.8 hPa at this hour, which was the lowest pressure recorded in association with the system. The pressure change (24 hr) and pressure departure of Agartala 0300 UTC of 5th were *minus* 12.6 hPa and *minus* 15.8 hPa. The maximum fall of pressure at Agartala was *minus* 3.0 hPa between 01 and 02 UTC of 5th, when the general diurnal tendency is rising one. Though the pressure change and the pressure departure of Agartala did indicate the severity of the system in the pressure field, the wind field was rather weak. At this hour Kailashahar wind was 10 kt from the east and in Bangladesh, Dhaka and Chittagong reported winds as NW/05 kt and SW/15 kt respectively. Thereafter, the system weakened rapidly and lay in the evening over Meghalaya and neighbourhood as a well marked low pressure area. It became unimportant over the same area by 6th morning.

According to satellite (INSAT) classification, the system attained the intensity of T 1.5 at 0000 UTC of 31 May and then T 2.0 at 0600 UTC of 2 June. The highest satellite classification was T 3.0, which the system attained at 0900 UTC of 4th.

The system had a life span of about 4 days over the sea. In the initial stage the development of the system was very slow. The intensification to cyclonic storm stage took place over north Bay when it was following a northeasterly course. The movement of the system was governed by the anticyclone in the mid-tropospheric levels over southeast Asia.

The storm ushered in southwest monsoon in Assam and adjacent States and caused active to vigorous monsoon conditions over these subdivisions on a couple of days. The significant amounts (cm) of rainfall were: Sonamure 14, Agartala AP 10, Cherrapunji 8, Kailashahar 7, North Lakhimpur and Shillong 5 each on 5th; Silchar AP 22, Cherrapunji 16, Arundhutinagar 14, Shillong 12, Lumding 9, Gangtok, Pasighat & Tadong 6 each on 6th.

As the storm did not strike the Indian coast, it caused no damage in India.

2.3. *Ongole cylonic storm, 14-19 October*

Under the influence of a cyclonic circulation extending up to mid-tropospheric levels, which was first observed over Andaman Sea on 10th, the system developed over west central and adjoining east central and southeast Bay on 14th morning. Initially, it moved northwestwards and then westnorthwestwards and crossed south Andhra coast just north of Ongole between 01 and 02 UTC of 16th, and weakened into a deep depression. It recurved from the morning of 18th and dissipated over Bihar plains and neighbourhood by 19th night. Track of the system is given in Fig. 1 and the ship observations in Table 6.

TABLE 6

Ship observations from 14 to 15 Oct 1987

Hr. of obsn. (UTC)	Call sign of the ship	Position		Wind		Remarks
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
		14 October				
0600	VTFY	12.1	84.2	020	14	
		15 October				
0600	ATBF	15.8	82.4	360	34	Overcast sky
0600	ATKL	16.0	82.3	020	30	Raining

The system was first detected in the INSAT imagery of 14th morning over central and adjoining southeast Bay. Cloud organisation in the imagery suggested ongoing intensification. Ship VTFY from about 300 km westnorthwest of the depression centre reported at 0600 UTC of 14th wind speed of 14 kt only from northnortheasterly direction. It moved northwestwards till the evening and then took a westnorthwesterly course and intensified into a cyclonic storm over west central Bay by 15th morning as was evidenced by the observation of the ship ATBF (which reported 34 kt wind from the north, Table 6 and INSAT imagery). However, the convection in the area of curved bandings increased at 0900 UTC of 14th, which acquired subsequently an inverted coma shape. Heading towards south Andhra coast it lay at 12 UTC of 15th about 200 km east of the coast. By this time the upper wind along the south Andhra coast strengthened. At 1200 UTC of the day winds at 0.9 km a.s.l. were NE/35 kt and WNW/25 kt at Machilipatnam and Madras respectively. However, the pressure changes (past 24 hr) along north Tamil Nadu-south Andhra coast on 15th evening were *minus* 2 to *minus* 3 hPa and the departures were *minus* 2 to *minus* 4 hPa only. The surface winds along south Andhra coast began strengthening from 2200 UTC of 15th (Fig. 3a). As per the wind observations of Ongole, the storm crossed south Andhra coast just north of Ongole between 01 and 02 UTC of 16th, as evidenced by Ongole winds which were 320°/22 kt and 200°/26 kt respectively, at those hours. When the storm crossed the coast on 16th morning the wind maxima of 200°/26 kt reported at 0200 UTC at Ongole and of 160°/26 kt at 0300 UTC at Machilipatnam. Also Ongole reported the lowest pressure of 995.1 hPa at 0200 UTC of this day. Cloud disorganisation took place very rapidly over coastal Andhra Pradesh in the morning of 16th to such an extent that the centre of the system could not be fixed at 0000 UTC with the help of satellite imagery. On crossing the coast the system weakened into a deep depression and lay at 0300 UTC of the day about 30 km northwest of Ongole. At this time the pressure change (past 24 hr) and departure at Ongole were —9.3 hPa and — 11.5 hPa respectively. The system further weakened into a depression over south Andhra by 16th evening, when it lay about 40 km east of Mahabubnagar. On 17th morning, when the depression lay over south Maharashtra, centred near Solapur, the winds in the lower tropospheric westerlies to the south of the depression centre strengthened. Gadag at 0000 UTC of 17th reported at 0.9 km a.s.l. 25 kt wind from westsouthwest. From 17th morning, the system took a northerly course and moved over north Madhya Maharashtra and adjoining Marathwada by 18th morning when it lay centred about 60 km northwest of Aurangabad. At 0300 IST of 18th the surface wind at Aurangabad was WSW/20 kt. On this morning the depression came under the influence of a mid and upper tropospheric trough in westerlies and it took a northeast to eastnortheasterly course. The depression moved over north Madhya Pradesh by next day morning when its centre lay about 50 km west of Satna. At this time on surface charts 3 closed isobars at an interval of 2 hPa could be drawn. By evening of 19th it lay over east Uttar Pradesh and adjoining Bihar plains centred about 100 km west of Patna. At this time the vertical depth of the associated cyclonic circulation reduced considerably. By midnight of this day, the system dissipated over Bihar plains.

The system had a total span of life of about 5 days of which, about two days, was over the sea area and the remaining three days over the land area. It was a cyclonic storm for a day only. The rate of intensification of the system was normal, *i.e.*, by one T-number in 24 hr. As per the Sat. Met., New Delhi report it had the intensity of T 1.5 at 0600 UTC of 14th, which became T 2.5 at 0200 UTC of 15th. The system attained a peak intensity of T 3.0 at 1200 UTC of 15th. It showed slight weakening after 1900 UTC and the T-classification at 2100 UTC of the day was T 2.5.

On 16th and 17th, the rainfall belt in association with the system extended upto south Orissa in the north. It gave a good spell of rain over south Orissa, Andhra Pradesh, Karnataka, west Maharashtra, Madhya Pradesh, plains of Uttar Pradesh and Bihar plains and Sub-Himalayan West Bengal & Sikkim. The significant amounts (cm) of rainfall were : Atchanta 22, Visakhapatnam 18, Chipurapalli, Kakinada, Mohana & Ongole 17 each, Amalapuram 12, Udaigiri 11, Kalingapatnam & Kashinagar 9 each, Berhampore 8, Nidadavele 7 on 16th; Pandharpur 17, Mohana 9, Talegaon 8, Mundali 7 on 17th; Koyna 29, Satara 15, Ashti 14, Jeur 13, Mahabaleshwar 12, Patoda 10, Seoni & Tuljapur 8 each on 18th; Tikamgarh 15, Guna 13, Bhor 12, Mahoba 11, Bahraich, Mahroni, Rajgarh & Rewa 10 each, Mandi 9, Banda, Basti, Bhopal, Kanpur AP & Sikahabad 8 each on 19th; Cooch Behar & Gantok 15 each, Araria, 10, Gorakhpur & Gauhati AP 9 each, Jalpaiguri 8, Takurganj & Una 7 each on 20th.

2.3.1. *Damage caused*—As per the reports, the storm took a toll of 17 human lives and affected a population of about 6.2 lakhs in 157 villages in Srikakulam Visakhapatnam, East Godavari, Krishna, Guntur and Prakasam districts of Andhra Pradesh. It also damaged about 9000 houses and crops worth about rupees 34 crores in those districts. The remnant

of the storm caused severe local storms at several places in Bihar plains on 19th and 20th, which took a toll of about 31 human lives there.

2.4. *Nellore severe cyclonic storm,* 31 *Oct-3 Nov*

A low pressure area, which was observed over southeast and adjoining southwest Bay of 30 October, concentrated into a depression on 31st morning. It further intensified into a cyclonic storm by that evening and into a severe cyclonic storm by the morning of 2 November. The system moved in a trochoidal path (Fig. 1) and crossed south Andhra coast just north of Nellore around 2200 UTC of 2 November. The remnant of the system emerged into east central Arabian Sea, across Konkan and Goa on 5 November and moved away westwards by next day. Relevant ship observations during the period from 31 October to 2 November are given in Table 7.

The system developed in the equatorial trough over the Bay of Bengal. In the satellite picture a prominent cloud cluster was observed over southeast Bay and adjoining Andaman Sea on 29 October. The deep layered and cyclonically curved convective clusters associated with the disturbance organised into a vortex covering an area of about 6 to 7 degree square over southeast and adjoining southwest Bay with its centre near Lat. 7.2° N, Long. 88.6° E by 0300 UTC of 30 October. On 31st morning satellite imagery indicated the formation of a depression over south Bay. 0300 UTC INSAT imagery of 31 October showed broken bands of intense to convective clouds spiralling into the system centre from the north and northeast sector. Also the 0000 UTC observation of ship ATAL (Table 7) was indicative of the development of an intense system over the south Bay. The system rapidly intensified into a cyclonic storm by 31st evening, when satellite imagery (INSAT) indicated its intensity as T 2.5 (35 kt). Ship URTO from about 350 km west of the storm centre, reported at this hour 27 kt wind from northeasterly direction (Table 7). The system moved in a northwesterly direction till the morning of 1 November and then in a westerly direction for the next 24 hours. The storm did not show further intensification from the evening of 31 October to the afternoon of 1st November. In the evening of 1st the T-classification of the system increased by 0.5 T-number and became T 3.0 (45 kt). However, on 1st no ship from the storm field reported gale force wind. At 0300 UTC of 2 November when the satellite imagery indicated the intensity of the system as a severe storm, it lay about 200 km eastnortheast of Madras (13.0°N, 82.0°E). At this hour the winds along north Tamil Nadu and adjoining south Andhra coast were between 05 & 10 kt. The upper wind at 0.9 km a.s.l. at 0000 UTC of 2nd at Madras was only northerly 30 kt. Gale force wind was reported by the ship ATJV and by ATKJ from about 450 km northeast and east respectively of the storm centre. It appears from the ship observations (Table 7) that the wind strength of 30 kt or more extended up to about 450 km to the rear sector of the storm. After 0300 UTC of 2nd the storm took a northwesterly course and lay at 1200 UTC of the day about 100 km east of Nellore. At this hour Nellore wind was NNW/20 kt. 10-15 kt wind along the coastline extended at this hour northwards upto south Orissa. Though the pressure departure at Nellore was *minus* 8.9 hPa, the change (24 hr) at the station was *minus* 6.1 hPa. As per the hourly observation of Nellore and Bapatla (Fig. 3b), the storm struck the coast around 2200 UTC of 2nd, just north of Nellore. The surface wind of Nellore was W/35 kt at 2200 UTC. At 2300 UTC the surface wind of the station became SSW/44 kt which was indicative of the storm centre over the land area. It also recorded the lowest pressure of 984.3 hPa at this hour. The station reported southerly wind of 40 kt at 0000 UTC of 3rd confirming the associated strong wind to its rear sector. CDMC station Kothapatnam (near Ongole) also reported wind NE/45 kt at 0000 UTC of 3rd. At 0300 UTC, it lay as a cyclonic storm about 60 km westnorthwest of Nellore. At this hour the pressure departures (24 hr) at Nellore and Ongole were *minus* 12.0 hPa and *minus* 10.5 hPa respectively. By evening, the system weakened into a depression over Rayalaseema and neighbourhood with its centre near Nandyal. It further weakened around midnight of 3rd over Rayalaseema and adjoining Telangana and interior Karnataka.

The system had a life span of a little less than 3 days over the sea area. The development rate of the system was normal except between the evening of 31 Oct and the evening of 1 November, when it was rather slow. As per the T-classification made on the basis of INSAT-imageries, it was 1.5 at 21 UTC of 30 October, which became 2.5 at 1000 UTC of 31st and 3.0 at 1200 UTC of 1st November. The system attained the peak intensity of T 3.5 at 0300 UTC of 2 November. It moved along the southern periphery of the sub-tropical ridge. An infrared picture may be seen in Fig. 5.

The system caused widespread rainfall with isolated heavy to very heavy falls over coastal Andhra Pradesh on 3rd and 4th, extreme north Tamil Nadu on 3rd and over Telangana on 4 November. Nellore recorded an unprecedented heavy rain of 52 cm on 3rd. As per reports, the rainfall was heavy to very heavy over Nellore district and neighbourhood from around mid-night of 2nd to around 0530 IST of 3rd. An isohyetal map based on rainfall data of 3 November has been shown in Fig. 2. The significant amounts (cm) of rainfall in association with the system were: Ponneri 24, Udayagiri 22, Kalingapatnam 18, Chembarambakkam & Sompeta 12 each, Gopalpur & Kakinada 11 each, Narsapur & Nenjur 9 each, Madras AP & Rapur 8 each, Rajampet & Tambaram 7 each on 3rd and Huzurabad 18, Tenali 17, Ibrahimnagar, Kalingapatnam & Nalagonda 16 each, Mahabubnagar & Sompeta 15 each, Rentachintala 13, Bobbili 12, Hyderabad AP 11, Kurnool & Visakhapatnam 8 each on 4th.

Also, as per the report Kavali experienced strong northerly winds of speed reaching 100 kmph from around 2nd mid-night to 0330 IST of 3rd. Wind weakened rapidly during 0330 IST to 0400 IST. Then again very strong wind from southeasterly direction commenced and continued up to 0600 IST of 3rd. These observations did indicate that perhaps the storm had developed an 'eye' prior to crossing the coast and the 'eye' region was over Kavali for about half an hour.

2.4.1. *Damages caused*—The storm affected a population of about 6.8 lakhs in 288 villages of Andhra Pradesh. It claimed a toll of 50 human lives and about 25,800 livestocks in the State. It also inundated vast stretches of paddy field, disrupted road and train services and damaged about 68,000 houses. The cost of the damages due to the storm was

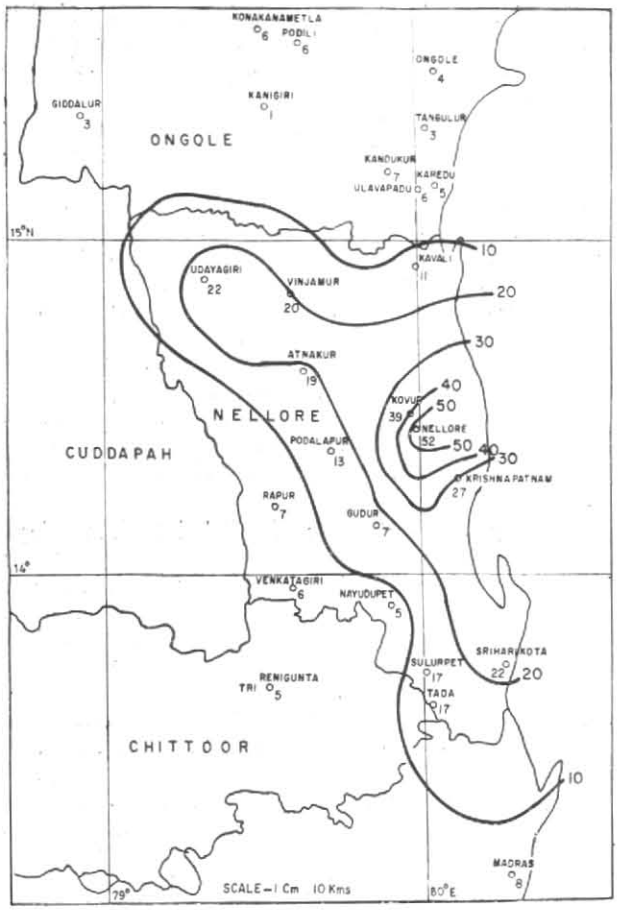
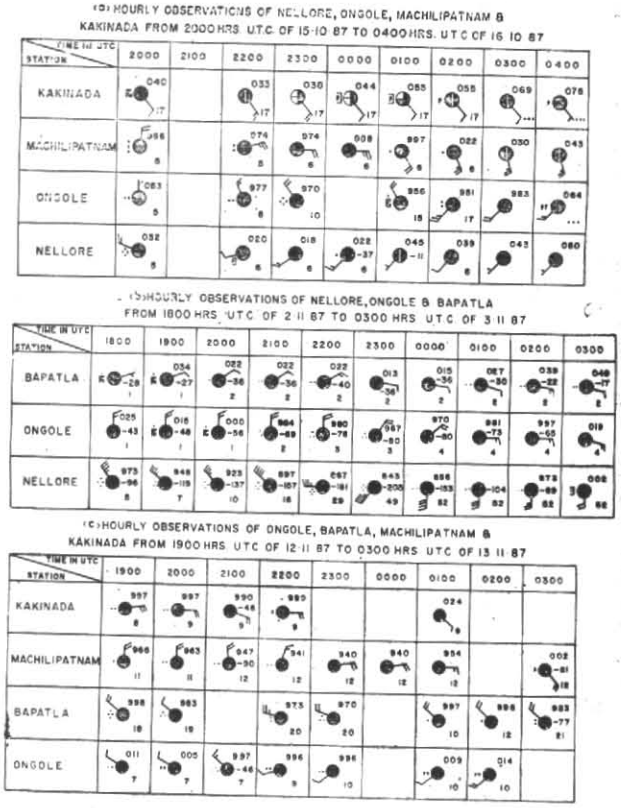


Fig. 2. Isohyetal map based on rainfall (cm) data of 3 November 1987



Figs. 3(a-c). Hourly observations

estimated to about rupees 60 crores. Nellore observatory reported gale force wind from 1800 UTC of 2nd to 0000 UTC of 3 November. As per reports of the State Government maximum damage occurred in the southwest quadrant of Nellore district north of Gudur. Though no storm surge inundated any coastal areas, the sea waters entered into Bukingham canal in Nellore district and breached its embankment. Saline waters from the swollen canal flooded the adjoining fields.

2.5. *Machilipatnam severe cyclonic storm,* 11-13 *November*

The storm developed in the seasonal trough over south Bay and adjoining Andaman Sea. During its life span, the system moved in a westnorthwesterly direction and crossed south Andhra coast on 13th just south of Machilipatnam around 0100 UTC. Ship observations from 11 to 13 November relevant to the system have been given in Table 8.

The system was a low pressure area over north Andaman Sea and neighbourhood on 9th. On the basis of INSAT imagery of 0600 UTC of 11th, the disturbance was a depression (T 1.5) over east central Bay and neighbourhood. 0600 UTC ship observations (Table 8) of 11th reported a strong belt of westerly winds over south Bay. By 1200 UTC the cloud features in the depression field became more organised, when the disturbance was in a broad field of strong upper tropospheric easterly current. It was steered westwards rather fast and by next day morning it lay over west central and adjoining southwest Bay. During its westward journey the system intensified into a cyclonic storm and lay at 0300 UTC of 12th centred near 14.5°N, 84.5°E. From the 0400 UTC observation of the ship ATML (Table 8) it was apparent that in the morning of 12th, winds of 30 kt strength extended up to a radius of 250 km from the storm centre. By 1200 UTC of 12th, the storm further intensified into a severe one. Ship VTBN (Table 8) which was about 150 km southwest of the storm centre reported wind speed of 41 kt. But surface wind speed along the coast, south of Lat. 16°N, were only 5 kt while to the north of this latitude 15-25 kt winds extended up to Visakhapatnam. However, at 0.9 km a.s.l. winds at Machilipatnam and Visakhapatnam were 360°/36 kt and 080°/50 kt respectively.

Later on, as the storm approached the coast, it gradually weakened. From the hourly observations, of Kakinada, Machilipatnam, Baptala and Ongole, which are given in Fig. 3 (c), it appeared that the system crossed coast as a cyclonic storm just south of Machilipatnam around 0100 UTC of 13th. The coastal stations, which recorded around 30 kt winds, were Machilipatnam at 1700 UTC, Kakinada between 1500 and 1900 UTC and Visakhapatnam at 1600 UTC of 12th. Also the lowest pressure of 994.8 hPa was recorded at 2300 UTC of 12th and 0000 UTC of 13th at Machilipatnam.

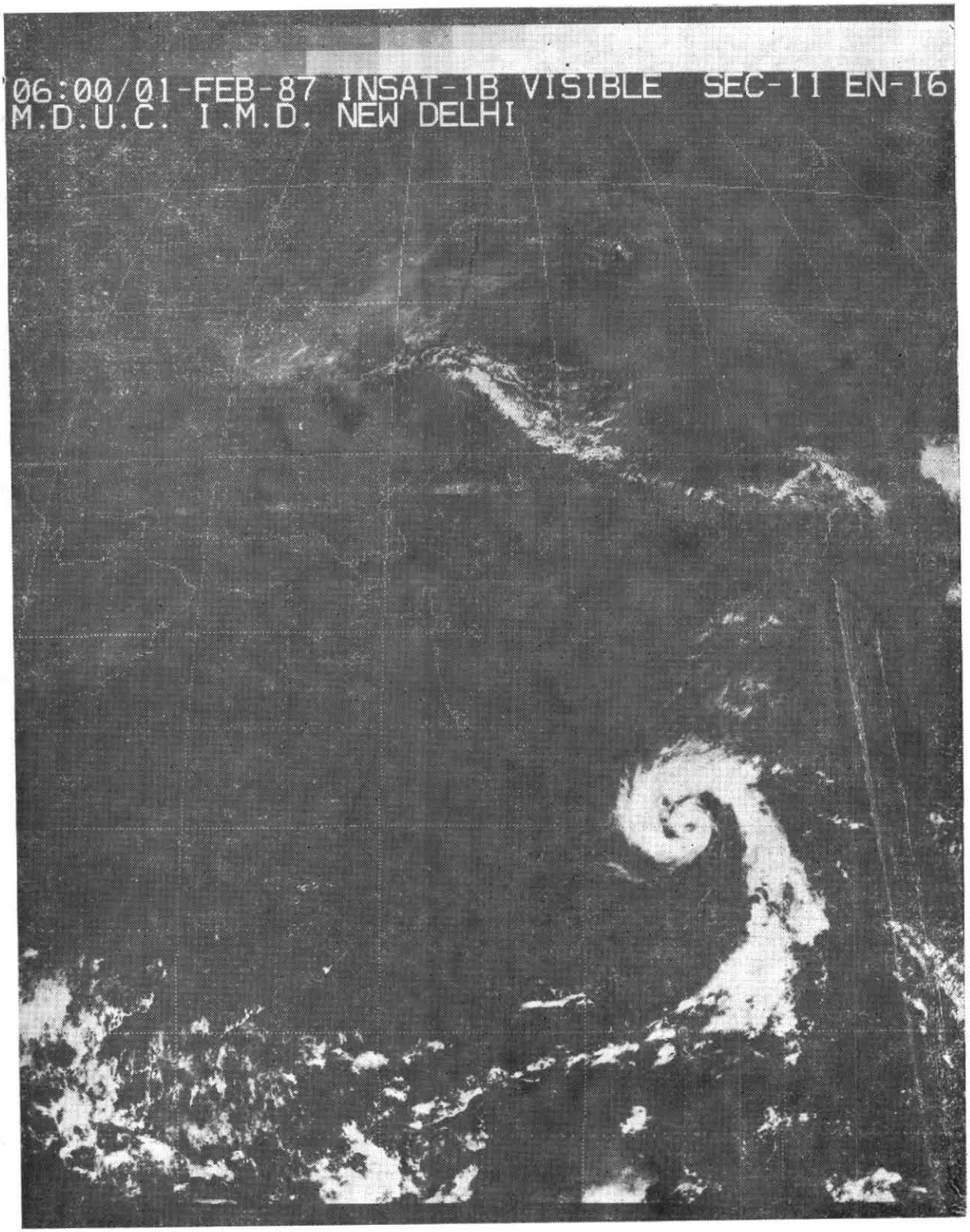


Fig. 4. INSAT - 1B visible picture of 1 February 1987 at 0600 UTC

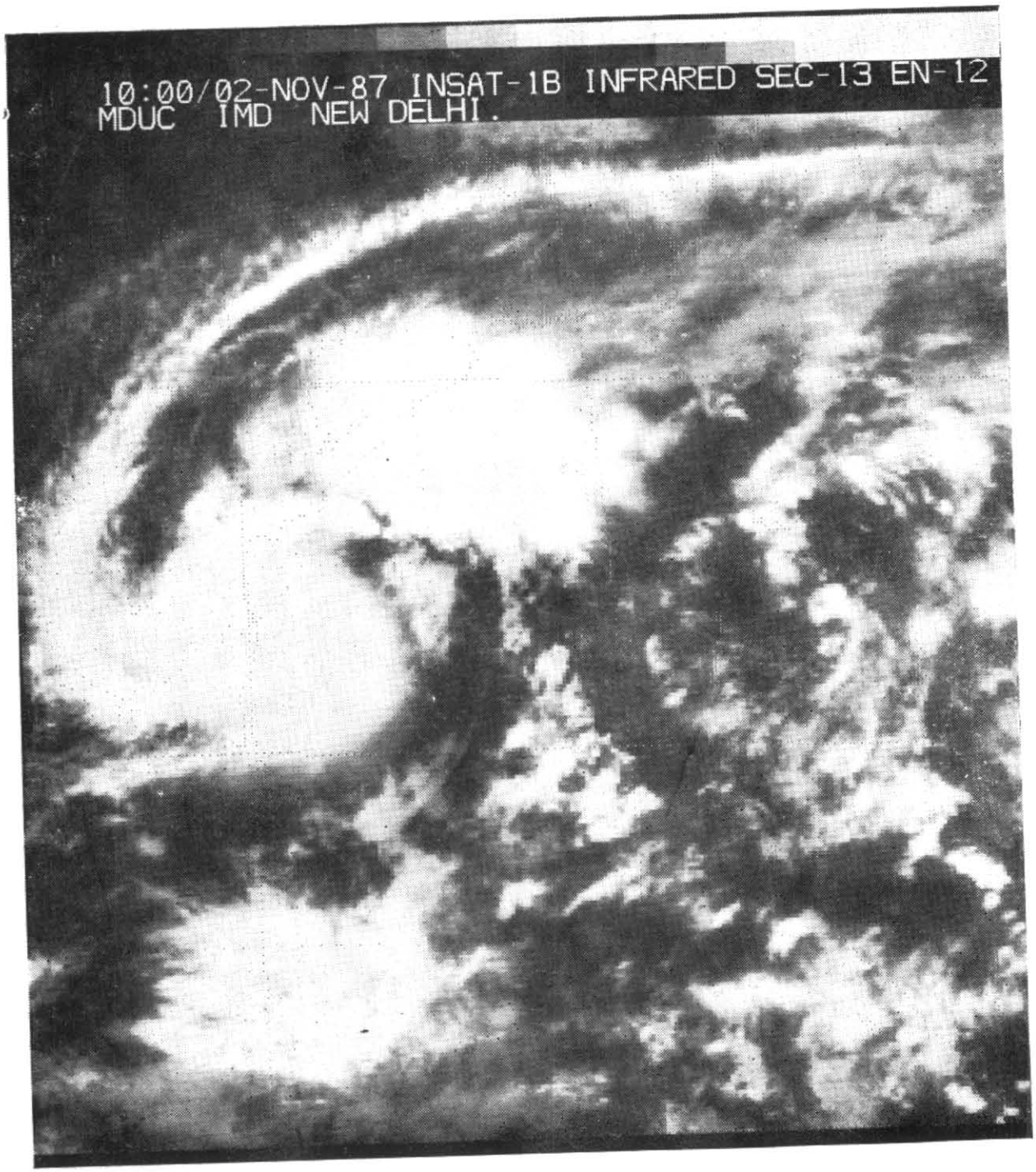


Fig. 5. INSAT - 1B infrared picture of 2 November 1987 at 1000 UTC

On crossing the coast the storm further weakened into a deep depression and lay at 0300 UTC of 13th about 50 km west of Machilipatnam. Ship observations (Table 8) from west central Bay on 13th morning reported wind speed of 20 kt. By evening the system further weakened over south coastal Andhra Pradesh and adjoining Telangana. However, the remnant emerged into Arabian Sea on 16th and dissipated over east central and adjoining northeast Arabian Sea off north Maharashtra-south Gujarat coast. As the system moved rather fast it had a sea travel of slightly less than two days. It also intensified very rapidly on 12th. From INSAT imageries it could be classified as T 2.5 at 0300 UTC, but by 0900 UTC, it attained its peak intensity of T 3.5. Cyclone Detection Radar (CDR), Machilipatnam also detected an 'open eye' of the system between 1400 and 1700 UTC of 12th.

The storm caused widespread rain with heavy to very heavy falls in coastal Andhra Pradesh and Telangana on 13th. The significant amounts (cm) of rainfall were : Nellore 18 on 11th; Atchanta 11 and Chipurupalli 10 on 12th ; Bapatla 21, Addanki and Tenali 15 each, Guntur 14, Machilipatnam 12, Kalingapatnam, Gopalpur, Ongole & Rentachintala 10 each, Kakinada, Nalgonda, Nasapur & Vijaywada 9 each, Ramannapet 8 and Suryapet 7 on 13th.

2.5.1. *Damages caused* — The system took a toll of 28 human lives and damaged about 8,400 houses in coastal Andhra Pradesh.

2.6. *Deep depression*, 19-22 *December*

The system developed in the equatorial trough on 19th. Initially, it took a northeasterly/northnortheasterly course and then moved in westsouthwesterly to westerly direction making a big loop over the sea. It weakened over southwest Bay off south Tamil Nadu-north Sri Lanka coast.

The northeast winds along north Tamil Nadu coast strengthened from 17th and the equatorial trough in the lower tropospheric levels over southwest Bay became active. The clouds over the region started organising from 17th evening and a vortex could be detected in the cloud organisation on 18th morning. Without much movement, the vortex developed into a depression by the evening of 19th and lay at 1200 UTC centred near 10.5°N, 82.0°E. At this time ship GOQG (9.1°N, 81.6° E) reported wind as 300°/27 kt and satellite imagery (INSAT) indicated its intensity as T 2.0. Though the system lay close to south Tamil Nadu coast, pressure changes (24 hr) and departures from normal along the coast were insignificant. The system remained practically stationary till the morning of 20th. Under the influence of a trough in mid and upper tropospheric westerlies, the sytem, thereafter, started moving northeastwards and away from Tamil Nadu coast. The depression moved rather fast after 20th evening and carried further away from the coast. The pressures along Tamil Nadu coast started rising and cloud organisations as seen in the INSAT imageries, became weak. On the basis of 1500 UTC INSAT imagery of 20th, the system ould be classified as T 1.0, which continued to be so at 0300 UTC of 21st. Though cloud organisations indicated weakening of the system after 1200 UTC of 20th, the ships on 21st showed the strengthening of wind field around the system. Ship VWNS (12.4°N, 84.5°E) at 0300 UTC and the same ship (11.4°N, 84.0°E) at 0600 UTC of 21st reported winds as 020° (46 kt and 250°/28 kt respectively indicating the further intensication of the system. Contrary to satellite classification, the system moving eastnortheastwards intensified into a deep depression and lay at 0300 UTC of 21st near 12.0°N, 84.5°E. Even ship ATUS (10.2°N, 82.2° E) at 0000 UTC reported wind as 300°/18 kt from about 300 km southwest of the centre of the deep depression. Observations from ship, in the evening of 21st indicated strong trade wind in the southwest Bay. Ship ATGT (11.2°N, 81.0°E) at 1400 UTC reported 30 kt wind from the north and ship VWNS (10.4°N, 83.7°E) at 1200 UTC reported wind 300°/16 kt. INSAT imagery at this hour indicated slight intensification of the system. The T-classification became 1.5 from 1.0. The system remained practically stationary throughout the day though it was associated with mid and upper tropospheric westerly flow.

After 21st evening, the deep depression took a westsouthwesterly course towards north Sri Lanka-south Tamil Nadu coast. On its westwards journey, the system weakened and lay at 0300 UTC of 22nd as a depression centred near 10.0°N, 82.0°E. Continuing its westward journey it came further close to south Tamil Nadu coast in the evening. At 1200 UTC of 22nd ships VTDT (11.3° N, 83.8°E), ATLH (10.5°N, 83.7°E) and VVNV (12.5° N, 83.8°E) reported winds as 140°/25 kt, 070°/20 kt and 040°/19 kt respectively. Surface winds along Tamil Nadu coast at this hour were north to northeasterly of 10 kt. The depression further weakened over southwest Bay off south Tamil Nadu-north Sri Lanka coasts by early morning of 23rd. The remnant moved across extreme south Peninsula and emerged into southeast Arabian Sea on 24th and then moved away westwards.

During its life span, the system made big loop over southwest Bay. Its initial northeasterly movement was in association with the middle and upper tropospheric trough in westerlies. But, later on it came under the influence of northeasterly current in the middle tropospheric levels, which apparently drifted it westwards, though westerly winds prevailed in the upper tropospheric levels in the region of the system.

According to INSAT imagery, it attained a peak intensity of T 2.0 (30 kt) by 0600 UTC of 19th and sustained that intensity at 1200 UTC. INSAT imagery of 1800 UTC of 19th indicated weakening of cloud organisation and the system could be classified at that hour as T 1.5. However, maximum wind in association with the system was recorded on 21st morning.

The system caused heavy rain over Tamil Nadu on 23rd and its remnant caused good rainfall over Tamil Nadu and Kerala on 24th. The significant amounts (cm) of rainfall were: Pooneri & Tiruvallur 4 each on 22nd; Adirampattinam 12, Vedaranyam 8, Chidambaram & Tiruthuraipoondi 7 each, Kumbakonam, Nagapattinam, Parangipettai & Thanjavur 5 each on 23rd and Chittoor 15, Coonoor 13, Pariyakulam 9, Kanchipuram, Srivilliputtur & Tiruttani 6 each, Kodaikanal & Pattambi 5 each on 24th.

TABLE 7

Ship observations from 31 October to 2 November 1987

Hr. of obsn. (UTC)	Call sign of ship	Position		Wind		Special remarks
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
		31 October				
0000	ATAL	12.2	84.4	030	22	
0600	ATAL	10.9	83.8	290	08	
0600	VTFY	13.9	83.0	030	17	
0900	ATAL	10.1	83.5	320	19	
1200	URTO	12.5	82.2	040	27	
1200	YQG2	9.6	81.5	340	25	
		1 November				
0300	VTKJ	11.5	84.3	280	25	
0600	VTKJ	12.0	84.3	280	27	Raining
0600	VTBN	14.8	82.0	320	22	Do.
0600	ATKG	17.0	88.6	130	24	Overcast sky
0900	VTKJ	12.6	84.5	300	22	Raining
1200	VTKJ	13.1	84.7	150	18	
1200	ATKG	15.7	87.7	090	25	
1200	ATFD	10.7	82.1	320	30	
1400	ATJV	16.8	84.0	070	30	
1500	VTKJ	13.8	85.0	090	25	
		2 November				
0000	VTKJ	15.7	85.7	060	32	
0000	ATKJ	13.5	86.2	140	50	Overcast sky
0300	VTKJ	16.3	86.1	090	30	
0300	ATVJ	16.1	85.6	SE	35	
0300	ATKG	13.0	86.0	160	33	
0900	ATJV	15.5	86.4	140	27	
1200	VWPX	12.7	82.5	220	25	

TABLE 8

Ship observation, 11-13 November 1987

Hr. of obsn. (UTC)	Call sign of the ship	Position		Wind		Special remarks
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
		11 November				
0600	9VXX	5.8	87.6	230	21	
0600	VRJL	5.3	80.9	270	30	
0600	3FXH	15.2	84.8	030	24	
		12 November				
0300	VTBN	14.8	81.5	350	22	
0400	ATML	16.7	86.1	110	32	Overcast sky
0600	ATML	16.6	86.3	110	28	Do.
0600	VTKL	17.5	86.6	110	23	Raining
0600	VWDG	17.9	90.4	130	30	—
0900	VTBN	15.1	81.7	310	40	Pr. 998. 2 hPa
1200	VTBN	14.7	81.5	300	41	Pr. 999. 5 hPa
1200	VTKL	16.4	86.1	110	26	Drizzling
1500	VTBN	14.2	81.7	280	40	
		13 November				
0000	VTKL	14.7	85.5	200	20	
0300	VTBN	14.5	83.0	240	20	
0600	VTBN	15.6	83.2	190	20	
0600	VTKL	13.6	85.1	200	20	

3. Land depression

3.1. *Depression*, 26-29 *August*

The system formed in the seasonal trough over north Bay as a low pressure area with associated cyclonic circulation extending upto mid-tropospheric levels on 24th. Moving northwards it concentrated into a depression over Bangladesh by the morning of 26th. Besides the cyclonic storm, which developed over the Bay of Bengal in the first week of June, this was the second intense system and the first monsoon depression of the monsoon season of 1987. The depression travelled westwards across West Bengal and Bihar and weakened over northwest Madhya Pradesh and neighbourhood. In the morning (0000 UTC) of 26th, lower levels wind strengthened at Gauhati. At 0.6 km and 0.9 km a.s.l. they became E/40 kt and E/35 kt respectively. In Bangladesh the winds at these levels at Bogra were reported as ENE/25 kt and ENE/30 kt respectively. The pressure gradient over Bangladesh and neighbourhood became quite strong. Over 4 degree square 3 isobars,at an interval of 2 hPa could be drawn at 0300 UTC of the day. Also the surface winds at this hour from the three Bangladesh stations, namely, Faridpur, Jessore and Dhaka were reported as NNW/05 kt, W/15 kt and WSW/20 kt respectively. The pressure departures from normal over Bangladesh were also *minus* 6 to *minus* 9 hPa. The depression lay at this hour about 50 km NNE of Faridpur. Moving westnorthwestwards, it lay in the evening over Bangladesh centred about 100 km southsouthwest of Bogra.

Continuing its journey westwards, the depression lay over Gangetic West Bengal by next day morning (0300 UTC) centred about 20 km northwest of Sriniketan. The wind strength in the lower levels continued to be strong at 0000 UTC of 27th. The surface wind strength around the system was about 10 kt both in the easterly as well as in the westerly fields. On this morning the pressure departures in the depression field ranged between *minus* 4 hPa to *minus* 8 hPa. The system speeded up from 27th morning and moved over Bihar by the evening of this day. At 1200 UTC it lay centred about 70 km eastsoutheast of Gaya.

After 27th evening the depression took slight southerly course and lay at 0300 UTC of 28th centred about 50 km south of Daltonganj. At this hour Ranchi reported surface wind southeasterly 20 kt. In the depression field three closed isobars at an interval of 2 hPa could be drawn. Beyond this point the depression took the usual westnorthwesterly course and moved by evening over northeast Madhya Pradesh and neighbourhood with its centre close to Sidhi. Sidhi reported lowest pressure of 991.6 hPa and a pressure change (past 24 hr) of *minus* 3.2 hPa at 1200 UTC of 28th. On 28th, the centre of the vortex in the satellite imageries (INSAT) was ill defined.

In the morning of 29th, the depression lay over north Madhya Pradesh and neighbourhood with its centre about 75 km westsouthwest of Satna. Winds in the depression field in the lower levels (0.6 km and 0.9 km a.s.l.) at 0000 UTC of 29th ranged between 25 and 35 kt and 3 closed isobars at an interval of 2 hPa could be drawn on sea level charts of 0300 UTC. In the evening (1200 UTC) the depression lay about 25 km southeast of Jhansi. At this time the surface winds in the southwest sector of the system strengthened. Sagar, Bhopal and Indore reported 20 kt winds from westsouthwesterly direction at the surface level. However, the strength of easterly winds in the northern sector of the system showed weakening. At 0.9 km a.s.l. wind at this time at Gwalior was E/10 kt only. Also dry northerly winds blew in the system in the lower and middle tropospheric levels. The depression weakened over northwest Madhya Pradesh and neighbourhood by next morning. The remnant became unimportant over plains of west Uttar Pradesh by the morning of 1 September.

The rainfall associated with the system was typical of a monsoon depression. It caused heavy to very heavy falls in its southern/southwestern sector, except in the early days when northeastern sector also received good rainfall. Under its influence active to vigorous monsoon conditions prevailed on a couple of days over Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Bihar, plains of west Uttar Pradesh, Madhya Pradesh and Vidarbha. Significant amounts (cm) of rainfall were : Calcutta AP 22, Sandheads 12, Midnapore 11, Triveni 9, Bankura, Jamshedpur AP & Patna AP 7 each on 26th; Bankura, Berhampore, Panagarh AP & Sriniketan 16 each, Sonamura 15, Jhumeritilaiya 11, Rajauli 10, Calcutta & Krishnanagar 8 each, Agartala AP, Belonia, Jamshedpur & Purulia 7 each on 27th; Bijnore 28, Morena & Simdega 18 each, Palkot 17, Bankura 16, Najibabad 14, Goalpara, Raisen, Sonamura & Vidisha 11 each, Purulia 10, Malda, Kashipur, Pantnagar & Ranchi AP 7 each on 28th; Tikamgarh 24, Nowgong 23, Pachmarhi 14, Sagar 13, Gadchiroli, Lalitpur & Morena 12 each, Bijnore, 10, Aligarh, Dhanbad, Jabalpur, Mandi, Muzaffarpur, New Delhi & Satna 9 each, Vidisha 8, Khajuraho 7 on 29th; Guna 18, Kishanganj 11, Sangod & Mangrol 10 each, Pachmarhi 9, Neemuch on 30th.

3.1. *Damages caused* — Following heavy rains there were floods in several rivers of northeast India. As per CWC reports there were floods in Bihar in river *Bagmati* at Hayaghat from 27 to 30 August, in river *Adhwara* group at Ekmighat from 27 to 29 August, in *Kosi* at Baltera, in *Ganga* at Gandhighat from 27 August to 2 September. In Orissa river *Subarnarekha* was in floods at Rajghat from 29 to 30 August. Heavy rain inundated many places in Hooghly district. Train services on Eastern Railways, Sealdah and Howrah Divisions were affected. Also flash floods engulfed vast areas of Murshidabad and Howrah districts.

3.2. *Depression,* 11-12 *September*

The system developed in the monsoon trough, which was active in the last week of August. It appeared as a vortex in the mid-tropospheric levels over northwest and adjoining west central Bay on 31 August. Further, it developed into a well marked low pressure area over northeast Madhya Pradesh and neighbourhood on 9 September. On 10th, another cyclonic circulation in the lower and middle tropospheric levels developed over northwest and adjoining west central Bay. This circulation moved inland and merged with the well marked low pressure area by 11th morning and concentrated into a depression by evening and lay centred about 30 km south of Ranchi. At this time Ranchi reported wind as 050°/03 kt. However, even in the morning, the circulation associated with the system was well organised and extended up to 300 hPa level. At 1200 UTC of 11th, the system was under the influence of westerlies/southwesterlies between 400 and 300 hPa levels but above 300 hPa level, it came under the influence of easterlies/southeasterlies associated with the anticyclone situated over southeastern parts of Tibet and northeast India.

The depression moved northwestwards and lay centred at 0300 UTC of 12th about 40 km west of Ranchi. At this time INSAT imagery showed well organised cloud cluster over Bihar and adjoining areas and Ranchi wind was 10 kt from 160 degree. The circulation associated with the system extended upto 500 hPa level. In the evening (1200 UTC) of 12th the depression lay over Bihar plateau and neighbourhood centred about 40 km west of Hazaribagh. From morning to evening, its movement was in a northerly direction, which was, perhaps, due to strong southerly winds over the system in the mid and upper tropospheric levels. At this hour Hazaribagh reported the lowest pressure of 993.6 hPa and very light wind from southeasterly direction. However, in the cloud field, the vortex centre was ill defined. By 13th morning the system weakened into a well marked low pressure area over southeast Bihar and neighbourhood. The system caused good spell of rainfall over Bihar and neighbourhood. The significant amounts (cm) of rainfall were : Dudhi 16, Chapra 14, Darbhanga & Motihari 11 each, Tensa 10, Malda 8, Chouldaghat & Turtipur 7 each on 12th; Dehri 18, Turtipur 15, Roberganj & Uluberia 9 each, Tezpur & Dudhi 8 each; Daltonganj 7 on 13th. The rainfall caused floods in river *Sone* at Koelwar and in river *Burhi Gandak* at Samastipur between 11 and 16 September.

3.3. *Depression,* 15-16 *September*

The remnant of the last depression remained practically stationary over Bihar Plateau and adjoining northeast Madhya Pradesh and neighbourhood for two days and reorganised. On 14th morning INSAT imagery showed curved convective lines. By the morning of 15th it again concentrated into a depression over northeast Madhya Pradesh. At 0000 UTC of 15th, Allahabad reported wind at 0.9 km a.s.l. as E/35 kt and Raipur

as WSW/25 kt. The cyclonic circulation associated with the system deepened and extended up to 400 hPa level without any apparent tilt with the height. The depression, at 0300 UTC of 15th lay centred about 30 km north of Pendra. At this hour three closed isobars at an interval of 2 hPa could be drawn on the sea level chart. Moving northwestwards, it lay centred at 1200 UTC of 15th about 40 km east of Umaria. At this time the system was comparatively less organised than the morning. On the surface two closed isobars of 2 hPa interval could be drawn, but the easterly wind strength to the north of the system weakened. Allahabad wind at 0.9 km a.s.l. at 1200 UTC weakened to E/25 kt. But, the lowest pressure of 998.1 hPa in association with the system was recorded at this hour at Umaria. Thereafter the depression moved in a westerly direction and lay next day (16th) morning centred about 50 km north of Jabalpur. At this time the pressure departures in the area of the system were on the negative side (1 to 1.5 hPa) excepting at Jabalpur where it was *minus* 1.9 hPa. However, in the southwestern sector of the systems a few stations, namely, Narsinghpur and Bhopal reported 15 kt winds. In the evening of 16th, the depression lay over northwest Madhya Pradesh centred about 60 km northwest of Damoh. At this hour the pressure departures from normal in the depression field became positive, which indicated that the system was weakening. However, the winds on 16th evening at 0.9 km a.s.l. around the system were 20 kt or so. By next morning, the system weakened into a low pressure area over northwest Madhya Pradesh. The remnant of the depression became less marked over north Madhya Pradesh and adjoining Uttar Pradesh by the evening of 19th. The system caused heavy to very heavy rainfall at a couple of places in Orissa, Madhya Pradesh and south Uttar Pradesh. The significant amounts (cm) of rainfall were : Kalpi 20, Bhind 18, Khajuraho 13, Bankura & Damoh 11 each, Cooch Behar, Jabalpur & Rajghat 9 each, Puri 8, Jhansi 7 on 16th and Mimgaoli 14, Shivpuri 13, Sironj 12, Akhuapada 11, Guna, Jalaun & Kolaras 9 each, Kalpi 8, Jhansi, Khurai & Tikamgarh 7 each on 17th.