Mausam, (1987), **38**, 1, 1-14

551.515.1(267) "1985"

Cyclones and depressions over the Indian seas and the Indian sub-continent in 1985

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(*Received 4 June 1986*)

1. Chief features

During the year 1985, the number of severe cyclonic storms, cyclonic storms and depressions was 2, 5 and 8 respectively, of which two depressions developed over land during monsoon season. A table showing the monthly variation of different types of disturbances is shown in Table 2.

During pre-monsoon season one severe cyclonic storm developed over the Bay of Bengal and a cyclonic storm over the Arabian Sea. In the monsoon season a cyclonic storm and three depressions formed over the Bay. Post-monsoon season witnessed the development of maximum number of storms and depressions, *i.e.*, 4 and 3 respectively of which only one depression developed over the Arabian Sea. Of the 4 storms, that developed over the Bay of Bengal, one was severe.

The tracks of these storms and depressions are shown in Fig. 1. Some of the important parameters related to the storms and depressions are shown in Table 1.

2. Bay of Bengal

2.1. *Bangla Desh severe cyclonic storm, 22-25 May*

A depression developed over central Bay on 22nd centred at 0300 GMT near Lat. 15.5°N, Long. 88.0°E. Remaining stationary it intensified into a cyclonic storm by evening. Then it moved northnorthwestwards till 23rd morning and again lay quasi-stationary at Lat. 16.5°N, Long. 87.5°E for 9 hours. Thereafter it took northnortheasterly course and intensifying into a severe cyclonic storm by the evening of 24th crossed Bangla Desh coast near Hatia in the early hours of 25th.

Satellite located the depression at 2100 GMT of 21st over east central Bay (16.0°N, 89.0°E) with the T number as 1.5 (25 kt). At 0330 GMT of 22nd the classification was T 2.0 (30 kt). There was no ship observation on 22nd from near the system. The evening satellite observation indicated that the system was practically stationary between the morning and the evening but developed further (T 2.5/35 kt). The disturbance was adjudged on the basis of satellite observation as a cyclonic storm at 1200 GMT of 22nd.

In the morning of 23rd when the storm lay centred near Lat. 16.5°N, Long. 87.5°E several ship observations from the southern sector of the system as given in Table 3 indicated the strengthening of the westerlies in west central and northern parts of south Bay.

Satellite classification at 0300 GMT continued to be T 2.5 but the system showed development thereafter and it became T 3.0 (45 kt) at 0600 GMT, which continued as such upto 1800 GMT of 24th. Satellite observation indicated that the system again remained quasi-stationary between morning and evening of 23rd. Oil India drilling rig (20° 11'N, 87° 27'E) reported winds as ENE/60 kt and NE/30 kt at 1000 GMT and 1130 GMT respectively of date. Ship *ATGH*(17.8°N, 89.8°E) at 1000 GMT and ship *VTBQ* (12.5°N, 84.4°E) at 1200 GMT reported winds 110°/25 kt and 230°/25 kt respectively. Sandheads wind at 1200 GMT continued to be 20 kt from the east. Observations of the Oil India drilling rig indicated that strong winds were blowing over seas off north Orissa coast but the coastal winds were between 5 and 15 kt on 23rd. Pressure departures along north Andhra-Orissa coast were —4 to —6 hpa. After 1200 GMT of 23rd the storm showed northnortheasterly movement and lay at 0300 GMT of 24th centred near Lat. 19.0°N, Long. 89.0°E. At this hour Sandheads (21.4°N, 88.0°E) showed backing and strengthening of winds. It reported winds as NE/30 kt. Ship *ATGH* (16.5°N, 92.0°E) from east central Bay reported wind 190°/37 kt. Also at 0000 GMT winds at 0.9 km a.s.l. at Calcutta and Balasore strengthened and became 050°/36 kt and 050°/30 kt respectively. Pressure departure maxima shifted to extreme north Orissa and Gangetic West Bengal coast which were of the order of —8 to —9 hpa. In the evening the winds at 0.9 km a.s.l. over Calcutta and Balasore reduced to NE/15 kt and NNE/25 kt respectively, while Bangla Desh stations reported strong easterly winds ranging from 30 kt to 55 kt at 0.9 km a.s.l. (070°/55 kt at Jessore, 110°/45 kt at Barisal and 110°/30 kt at Chittagong). Even at surface, Chittagong wind at this hour was ESE/30 kt and that at Jessore was ENE/20 kt. The wind observations were indicative of its intensification, though the cloud pattern did not reflect it. It was a severe cyclonic storm at 1200 GMT centred near Lat. 20.5°N, Long. 90.0°E. Satellite imageries indicated rapid intensification of the system after

TABLE 1

Details of depressions/cyclones originated in the Bay of Bengal and Arabian Sea during 1985

S. No.	Type of disturbance	Life period	Point of crossing coast with date	Central pressure Lowest pressure	Max. wind speed reported	Max. wind speed estimated/ T-number with date	Storm surge ht estimated/ reported	Loss of life/property damage reported
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1. Details of depressions/cyclones originated in the Bay of Bengal during 1985							
(1)	Severe cyclonic storm	22-25 May	Hatia in Bangladesh, early in morning of 25th (24/2200 GMT)	—	(1) ENE/55 kt evening of 24th (Jessore) (2) WSW/50 kt morning of 25th (Chittagong)	24/18GMT T3.0 (45 kt) 24/20GMT T 3.5 (55 kt) 24/21GMT T 4.0 (65 kt)	4.5 m	Thousands of human lives and cattle heads reported to have seen lost in Bangladesh. It caused floods in Comilla and Sylhet districts.
(2)	Depression	1 Aug	North Orissa coast near Chandbali in the early hours of 2nd.	—	Sandheads 080/15kt at 03GMT	—	—	—
(3)	Depression	6-9 Aug	West Bengal coast near Sagar Island on noon of 6th	..	300/10 kt (Sandheads)	—	—	—
(4)	Depression	14-15 Aug	North Orissa coast near Chandbali in the morning of 15th	—	—	—	—	—
(5)	Cyclonic storm	19-21 Sep	Orissa coast near Puri around 1230 GMT	9937. hpa pressure recorded at Puri on 20/12 GMT	40 kt (Puri) on 20/1230GMT	T 3.0 (45 kt) on 20/0300GMT	2.8 m	6 fishermen were drowned in Chilka lake. The storm caused widespread damage to crops, roads and prawn culture tanks.
(6)	Depression	1-2 Oct	Near Ongole on the forenoon of 2nd	—	—	T 1.5 (25 kt) on 1st	—	—
(7)	Cyclonic storm	9-12 Oct	North Andhra coast near Visakhapatnam during early hours of 11th.	—	Ship *ATJV* 350/ 40kt at 1200GMT of 10th	T 3.0 (45 kt) on 23/0000GMT	—	Damage to crops & properties was estimated at abovt 31 lakh
(8)	Severe cyclonic storm	13-17 Oct	North Orissa coast near Balasore early hours of 16th	987.8 hpa (Balasore) at 22 GMT of 15th	45 kt at 15/1200 Ship *VTJR* 300/ 50 kt at 0000 GMT of 15th	T 3.0 (45 kt) on 15/0800GMT to 16/0000GMT	3-3.5 m (Sagar and Gasaba Islands) 1.5-2m (Balasore Dist.)	(*i*) 84 persons died and 34 reported missing.
							2m (coastal areas of Contai sub-division)	(*ii*) 30966 houses collapsed in West Bengal and 8703 in Orissa.
								(*iii*) 2643 cattles heads perished. 4 lakhs hectre area was affected.
(9)	Depression	12 Nov	Not crossed the coast, but centred very close to coast about 40 km south of Tambaram in the evening of 12th	—	50 kt (gusty) 12/0500GMT	—	—	As reported in the press 50,000 huts were damaged in low lying areas of Madras city.
(10)	Cyclonic storm	15-17 Nov	Dissipated over the west central Bay on 18th	—	330°/24 kt on 15/0600GMT	T 2.5 (35 kh) 16/1200GMT	—	—
(11)	Cyclonic storm	11-14 Dec	South Andhra coast at Sriharikota around 18GMT of 13th	996.0hpa (Madras on 12GMT of 13th), 998.0 hpa (Sriharikota) at 1728GMT of 13th	010/54 kt (Sriharikota on 13/17GMT)	T 3.0 (45 kt) on 12/0900GMT		12 persons reported to have been killed and four villages cut off due to floods in Swarnamukhi river and Mandi canal in Nellore district

TABLE 1 (*contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			2. Details of depressions/cyclones originated in the Arabian Sea during 1985					
(1)	Cyclonic storm	28-30 May	Dissipated over north-east Arabian Sea by morning of 31st	—	N/45 kt	T 3.0 (45 kt) on 29/1200GMT	—	—
(2)	Depression	6-9 Oct	Crossed south Gujarat coast south of Bulsar on forenoon of 7th	—	—	T 1.5 (25 kt) on 06/0900GMT	—	—
			3. Details of land depressions formed during 1985					
(1)	Depression (Northwest Rajasthan)	5-6Aug	—	—	—	—	—	—
(2)	Depression (Northwest Madhya Pradesh)	23-24 Sep	—	1000.8 hpa (Gwalior)	—	—	—	—

TABLE 2

Monthly variation of different types of disturbances during 1985

Type of disturbance	J	F	M	A	M	J	J	A	S	O	N	D	Total
						Bay of Bengal							
Depression	—	—	—	—	—	—	—	3	—	1	1	—	5
Cyclonic storm	—	—	—	—	—	—	—	—	1	1	1	1	4
Severe cyclonic storm	—	—	—	—	1	—	—	—	—	1	—	—	2
Severe cyclonic storm with a core of hurricane winds	—	—	—	—	—	—	—	—	—	—	—	—	—
						Arabian Sea							
Depression	—	—	—	—	—	—	—	—	—	1	—	—	1
Cyclonic storm	—	—	—	—	1	—	—	—	—	—	—	—	1
Severe cyclonic Storm	—	—	—	—	—	—	—	—	—	—	—	—	—
						Land							
Depression	—	—	—	—	—	—	—	1	1	—	—	—	2
Total	—	—	—	—	2	—	—	4	2	4	2	1	15

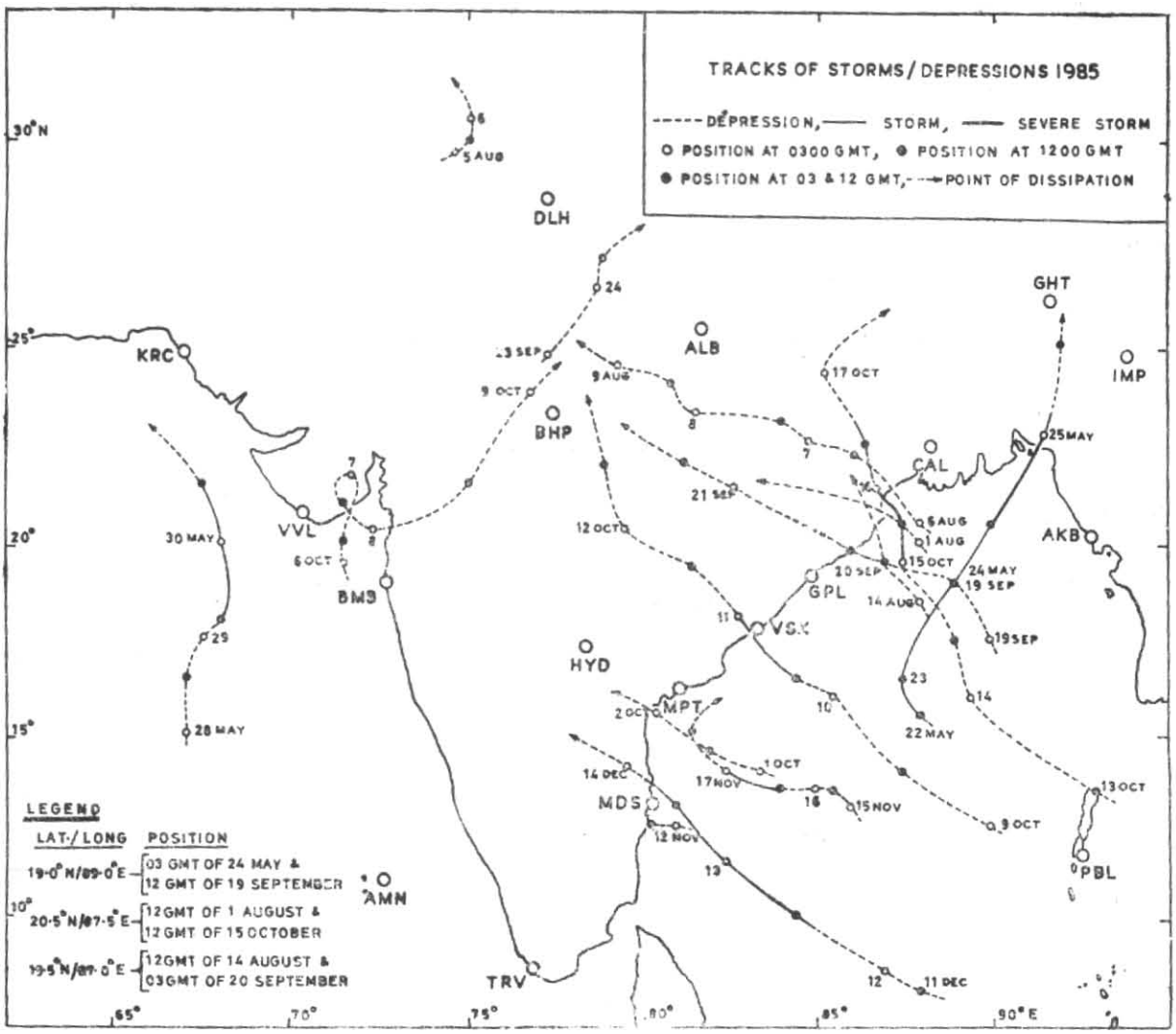

Fig. 1. Tracks of storms/depressions during January-December 1985

TABLE 3

Ship observation in Bay

Call sign of the ship	Date Time of obsn. in GMT	Position Lat. (°N)	Position Long. (°E)	Wind Direction (°)	Wind Speed (kt)	Remarks
V TBO	23/0300	14.8	85.6	270	20	Overcast sky
Sand-heads	23/0300	—	—	090	20	Do.
ATIU	23/0600	12.5	84 8	230	24	Do.
YSKE	23/0600	12.5	88.3	240	29	Do.

1800 GMT of 24th. It could be classified as T 3.5 (55 kt) at 2000 GMT and as T 4.0 (65 kt) at 2100 GMT. The system crossed Bangla Desh coast near Hatia around 2200 GMT.

At 0300 GMT of 25th it lay as a severe cyclonic storm about 50 km northnorthwest of Chittagong. At this time surface wind at Chittagong was WSW/50 kt. Thereafter, it weakened into a depresson by evening over Meghalaya and neighbourhood and lay centred at 1200 GMT near Lat. 25.0°N, Long. 92.0°E. At this time surface wind at Gauhati was 090°/15 kt and that at 0.9 km a.s.l. 080°/25 kt. Agartala also at 0.9 km a.s.l. reported wind as 270°/30 kt. By next day morning the system weakened over Assam and Mehgalaya and neighbourhood.

From 22nd morning to 23rd morning the anticyclones at 200 and 250 hpa levels were over or just NE of the system when these were quasi-stationary or were moving very slowly. Marked shifting of these anticyclones to the east of the disturbance was observed at 1200 GMT of

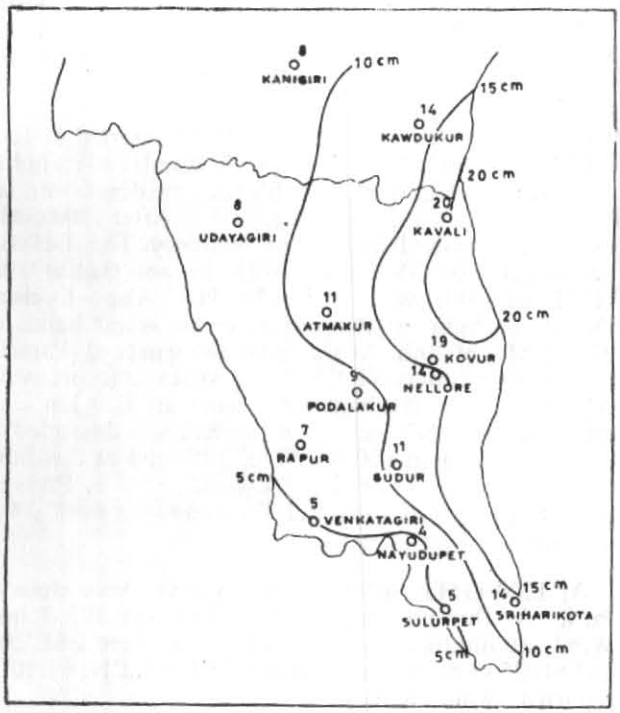

Fig. 2. Cumulative rainfall in Nellore district for three days, 13-15 December 1985

23rd after which the northwards movement of the system became prominent.

The system caused widespread rain all over Assam & adjacent States and Gangetic West Bengal on one day each. According to Central Water Commission report rivers *Longa* and *Shingla*, tributaries of river *Barak*, were in floods on 26 and 27 May. 9 villages in Karimganj district were affected by floods. Also river *Juri*, *Gumti* and *Manu* in Tripura were in floods on 27th. According to press reports the storm left a trail of devastation in coastal Bangal Desh affecting about 2.5 million people. Several coastal villages were almost completely swept away by high tidal waves of about 4.5 metres height. Thousands of human lives and cattle heads reported to have been lost in that country. Also, It caused floods in Comilla and Sylhet districts.

2.2. *Depression, 1 August*

A cyclonic circulation in the middle tropospheric levels was observed over west central and adjoining northwest Bay off north Andhra-south Orissa coasts on 30 July. By next day a low pressure area developed over northwest and adjoining west central Bay off south Orissa-north Andhra coast, which concentrated into a depression in the morning of 1 August centred at 0300 GMT near Lat. 20.0° N, Long. 88.0°E. At this time Sandheads reported wind 080°/15 kt. The winds at the coastal observatories of Orissa were 5 to 10 kt. Moving northwestwards it lay in the evening (1200 GMT) centred near Lat. 20.5°N, Long. 87.5°E. Wind at Sandheads veered to SE/15 kt and that at Balasore was EME/15kt. Wind at 0.9 km a.s.l. at Balasore strengthened from morning's 25 kt to 35 kt in the evening. Pressure change for the past 24 hours along Orissa coast was −2 to −3 hpa both in the morning and evening of this day. The system moved westnorthwestwards and crossed north Orissa coast near Chandbali in the early hours of 2nd and lay at 0300 GMT as a well marked low pressure area over northwest Orissa and adjoining east Madhya Pradesh. Continuing to move westnorthwestwards across Madhya Pradesh and east Rajasthan the remnants lay over central parts of Rajasthan on 4th. Under the influence of this system monsoon became active in Orissa on 1st and 2nd and Gangetic West Bengal and Bihar Plateau received generally widespread rain on 2 to 3 days. The significant amounts (cm) of rainfall associated with the system were : Perur 14, Kothagudam 12, Polavaram, Paradip, Bhubaneswar & Kakatpur 11 each, Daitary 9, Chandbali 8, Puri 7 on 1st; Akhuapada 19, Khairamal 18, Sambalpur 17, Hirakund 14, Jenapur12, Sironj, Rairakhol & Rajkishorenagar 11each, Talchar & Deogarh 10 each on 2nd; & Baramul & Tikamarh 12 each, Khurai 11, Guna 10, Shivapui & Mandla 9 each, Bhopal, & Ambabhona 8 each on 3rd.

2.3. *Depression, 6-9 August*

A low pressure area with associated cyclonic circulation extending upto mid-tropospheric levels developed over north Bay and adjoining Bangla Desh on 4th. It concentrated into a depression over northwest Bay on 6th morning centred at 0300 GMT near Lat. 25.5°N, Long. 88.0°E. The winds at 0.9 km a.s.l. reported at 0000GMT of 6th from Calcutta and Balasore were 105°/23 kt and 025°/20 kt respectively. It moved northwards rather fast and crossed West Bengal coast near Sagar Island around noon. At 0600 GMT Sandheads stationed at Lat. 22° 11'N, Long. 88° 11'E reported wind 300°/10 kt and Calcutta reported 090°/10kt. After crossing coast it changed its course to a westnorthwesterly direction and lay at 1200 GMT centred about 50 km south of Jamshedpur. The surface winds along Orissa coast at this time, were 10 to 15 kt, but inland winds were only about 5 kt. On 7th morning (0300 GMT) it lay over Bihar Plateau and neighbourhood centred about 100 km west of Chaibasa. Pressure changes for the past 24 hours and the departures in the depression field were of the order of −4 to −5 hpa and −6 to −7 hpa respectively. Surface winds in the depression field, however, were around 5 kt only. Continuing to move westnorthwestwards it lay at 1200GMT centred over Jashpurnagar. Surface winds continued to be weak (*i.e.*, around 5 kt).

The system, then moved westwards and lay over east Madhya Pradesh on 8th morning centred about 75 km ESE of Umaria and in the evening about 60 km SSE of Satna. From 8th morning the clouds showed disorganisation. The surface winds in the depression field both in the monring and evening were 2 to 5 kt but the winds at 0.9 km a.s.l. ranged between 20 & 30 kt.

On 9th morning, the system still retained its intensification as a depression and lay at 0300 GMT centred about 50 km SSE of Tikamgarh. At this time two closed isobars at an interval of 2 hpa could be drawn. By evening the system weakened into a low pressure area over northwest Madhya Pradesh and adjoining plains of west Uttar Pradesh.

Under the influence of the system monsoon became active to vigorous in Orissa on 6th and 7th, in east Madhya Pradesh on 7th and 8th, in west Madhya Pradesh from 7th to 9th and in east Rajasthan on 9th and 10th. Bihar Plateau received widespread rainfall from 6th to 8th with isolated heavy fall on 6th. The significant amounts (cm) of rainfall were : Boudhgarh & Sonepur 23 each, Phulbani 22, Khairmal 20, Rairakhol 17, Jamankhira

13, Sambalpur, Talkoi 11 each, Jamshedpur 10, Bolangir, Chandbali 9 each on 6th; Khairmal 18, Sambalpur 15, Champa 13, Belgaon 12, Bolangir 11, Titlagarh 10, Guna 9, Sakti 8, Satna, Khurai & Baripada 7 each on 7th, Sagar 17, Khurai 15, Datia 14, Pathalgaon 13, Sironj 12, Jabalpur & Narsinghpur 11 each, Shivpuri 10 on 8th; Shajapur, 27, Vidisha 26, Rajgarh 20, Raisen 19, Bhopal 17, Khanpur 14, Jhalawar, Guna & Panchmari 12 each, Damoh & Sangod 10 each on 9th ; Kapatan 9, Rawatbhata 7 on 10th.

Rivers *Baitarani* and *Mahanadi* were in floods affecting Cuttack, Puri, Balasore, Bolangir, Keonjhar and Sambalpur districts of Orissa. The river *Narmada* was in floods at Mandla during 8 to 10 August submerging the road bridge.

2.4. *Depression, 14-15 August*

A cyclonic circulation in the lower and middle tropospheric levels was observed over northwest and adjoining west central Bay on 9th evening. Under its influence a low pressure area developed there on 13th, which concentrated into a depression on 14th and lay centred at 0300 GMT near Lat. 18.5°N, Long. 88.0°E. At 0000 GMT Bhubaneswar wind at 0.9 km a.s.l. was 040°/23 kt. It moved slowly northwestwards along the seasonal trough and lay at 1200 GMT centred near Lat. 19.5°N, Long. 87.0°E. The wind at 0.9 km a.s.l. at Bhubaneswar backed and became 065°/17 kt in the evening. The winds along the Orissa coast were light and from northeast to northwesterly direction. INSAT-1B imagery of 0630 and 0900 GMT showed curved cumulus lines indicating inflow in the lower tropospheric circulation field.

The system crossed north Orissa coast near Chandbali in the morning of 15th and weakened into a well marked low pressure area, which lay at 0300 GMT over north Orissa and neighbourhood. The low pressure area persisted there till 16th morning and then moving northwestwards it merged with the seasonal trough over central Uttar Pradesh and neighbourhood on 19th. The system caused active to vigorous monsoon condition on 1 to 2 days in Orissa, east Madhya Pradesh, Vidarbha and coastal Andhra Pradesh. Fairly widespread rainfall occurred on a couple of days in Bihar Plateau. Significant amounts (cm) of rainfall were : Sompeta 20, Titlagarh 8, Mohana & Khammam 7 each on 14th; Paikmal 11, Perur 8 on 15th; Panposh 10, Rajgarh & Joshipur 8 each, Cuttack, Sambalpur, Barmul & Nawrangpur 7 each on 16th; Narsinghpur 11, Paikmal 10, Baihar 9, Balaghat & Durg 7 each on 17th.

2.5. *Bay cyclonic storm, 19-21 September*

Under the influence of a cyclonic circulation extending upto mid-tropospheric levels, which moved from the east across Thailand, south Burma and north Andaman Sea, a depression developed over east central Bay near 17.5°N, 90.0°E on 19th morning. For next 9 hours it moved northwestwards and then westnorthwestwards and intensified into a cyclonic storm near 19.5°N, 87.0°E on 20th monrning. It crossed Orissa coast near Puri around 1230 GMT of 20th and weakened into a depression. Continuing to move westnorthwestwards it weakened over northeast and adjoining west Madhya Pradesh on 22nd.

At 0000 GMT ship *VTJR* (17.6°N, 89.6°E) reported wind 360°/18 kt. Satellite classification of the system at 0330 GMT of 19th was T-1.0 and that from 0900 GMT to 1200 GMT T-1.5. On the basis of the *VTJR* wind the system was adjudged as a depression on 19th morning. The same ship from the same position reported at 1200 GMT of date wind 200°/22 kt while Sandheads wind at this hour was NE/10 kt. At this time the depression lay centred near Lat. 19.0°N, Long. 89.0°E. After 1200 GMT the system showed developing tendency. The T-classification at 1500 GMT was 2.0 (30 kt) and that at 0300 GMT of 20th was 2.5 (35 kt). Also, Cyclone Detection Radar at Paradip observed spiral bands at 0300 GMT of 20th. At this hour the winds at Paradip and Sandheads were NE/25 kt and SE/15 kt respectively. At 0000 GMT Bhubaneswar wind at 0.9 km a.s.l. reported to be N/40 kt. The system was upgraded to a cyclonic storm at 0300 GMT of 20th and at this hour it lay centred near Lat. 19.5°N, Long. 87.0°E. Pressure changes (24 hr) at Puri and Bhubaneswar were —6.4 hpa and –5.3 hpa respectively.

At 1200 GMT the storm lay over sea very close to Puri. At this hour pressure at Puri was 993.7 hpa. Winds at Bhubaneswar and Sandheads were ESE/20kt and SE/25 kt respectively. Ship *VTKK* (18.2°N, 86.10°E) reported wind S/20 kt.

The storm crossed coast around 1230 GMT of 20th near Puri when the station recorded maximum wind speed of 40 kt. The highest T-classification for the system was 3.0 (45 kt) at 0800 GMT of 20th.

On entering land the system weakened into a depression and lay at 0300 GMT of 21st over east Madhya Pradesh and adjoining Orissa centred about 70 km south of Champa. The surface winds in the depression field were 5–10 kt but Gopalpur and Puri reported at this time southerly winds of 15 kt and 20 kt respectively. In the evening the depression lay centred about 100 km northnorthwest of Raipur. Satellite observations showed the weakening of the system from 0900 GMT of 21st. By 1500 GMT the vortex centre in the satellite imagery became ill defined. By 22nd morning the depression weakened into a well marked low pressure area over northeast and adjoining west Madhya Pradesh.

Paradip recorded average wind speed of 36 kt between 0530 & 0930 GMT of 20th with maximum gust of 47 kt at 0735 and 0855 GMT. On this day Paradip Port Trust reported rise of 2.8 metres in sea level with normal tide and that off the shore of Puri was 1 metre. According to reports six fishermen were drowned in Chilka Lake. Due to tidal bore in river *Devi* several villages in Ashtrang block of Puri district in Orissa were submerged under 1 m of water. It caused widespread damages to paddy crops, roads and prawn culture tanks in several blocks of Puri district.

Significant amounts (cm) of rainfall in association with the system were : Banpur 11, Gop & K. Prasad 10 each, Kakatpur, Bhubaneswar & Chilka 9 each on 20th; Banpur 17, Rajnandgaon, Bolangir 15 each, Mudhabaida 14, Nawapada 12, Madanapur 11, Raipur, Phulbani, Belgaon, Janapur & Surada 9 each on 21st; Kawardha 28, Raisen 13 & Vidisha 10 on 22nd.

2.6. *Depression, 1-2 October*

Under the influence of a cyclonic circulation extending to mid-tropospheric levels, which moved westwards from Gulf of Siam, a well marked low pressure area developed over southeast and adjoining southwest Bay in the evening of 29 September. It concentrated into a depression over west central Bay by the morning of 1 October centred near Lat. 14.0°N, Long. 83.5°E. Following westnorthwesterly course, it lay in the evening near Lat. 14.5°N, Long. 82.0°E. From the satellite imagery of 1200 GMT the intensity of the system could be classified as T-1.5 (25 kt) but at the same time the centre of the system was ill-defined. On this day surface winds along north Tamilnadu and south Andhra coasts were of the order of 5 to 10 kt. In the pressure field, 24-hr changes and departures from normal were not significant.

At 0300 GMT of 2nd, surface wind at Ongole was N/10 kt and that at Machilipatnam was SE/20 kt. Machilipatnam at 0000 GMT of 2nd reported a wind of ESE/25 kt at 0.9 km a.s.l. The depression though lay very close to the coast east of Ongole, did not cause any significant pressure fall (past 24 hr) or pressure departure along the south Andhra coast. Probably the system was rapidly weakening. It crossed coast near Ongole in the forenoon of 2nd and weakened into a low pressure area over south Andhra. The system caused active to vigorous monsoon conditions on 1 to 2 days in Andhra Pradesh and coastal Karnataka. The significant amounts (cm) of rainfall were : Visakhapatnam & Tokkali 12 each, Avenigadda 11, Machilipatnam 9, Kakinada & Yemmiganur 8 each on 2nd; Kalvakurthy 20, Shirali 19, Honavar 14, Agumbe 12, Nagarjunsagar & Badvel 10 each, Mangalore AP 9, Sullurpet, Devarakonda & Karwar 7 each on 3rd.

2.7. *Visakhapatnam cyclone, 9-12 October*

A cyclonic circulation extending upto mid-tropospheric levels was observed over Gulf of Siam and neighbourhood on 7th. Moving westwards it emerged into Andaman Sea and developed into a depression over southwest Bay on 9th. Moving in a westnorthwesterly direction it intensified into a cyclonic storm over west central Bay on 10th evening. Continuing to move westnorthwestwards the storm crossed north Andhra coast near Visakhapatnam in the early hours of 11th. Thereafter, it took a northwesterly to northerly course and dissipated over northwest Madhya Pradesh and neighbourhood by 13th.

The equatorial trough over Bay was quite active prior to the formation of this storm. Bay island stations were reporting rainfall daily for last 4 to 5 days. On the basis of 0300 GMT INSAT imagery of 9th the system was classified as T-1.5 (25 kt). There were no ship observations from the area. On the basis of the satellite observation the system was declared as a depression at 0300 GMT of 9th centred near Lat. 12.5°N, Long. 90.0°E. Satellite classification was T-2.0 (30 kt) at 0600 GMT and T-2.5 (35 kt) at 1200 GMT. However, ship *ATJV* (13.7°N, 87.6°E) reported wind 270°/20 kt at 1200 GMT of this day. As per the report the ship experienced continuous rain for last 24 hr. In view of this observation, the system was upgraded to a deep depression in the evening centred Lat. 14.0°N, Long. 87.5°E. Subsequent satellite observations did not indicate further intensification of the system. At 0300 GMT of 10th the classification continued to be T-2.5. The ship observations (Table 4) were received from the field of the deep depression.

TABLE 4

Ship observations on 10 October

Call sign of the ship	Time of obsn. (GMT)	Position		Wind	
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)
VTBO	0000	12.5	83.9	260	24
ATJV	0300	15.5	85.3	290	20
ATJV	0600	16.2	84.6	360	20

TABLE 5

Visakhapatnam observations on 10 October

Hour of obsn. (GMT)	Wind		Pressure (in tenth's decimal place (hpa)	Rainfall (cm)
	Dir. (°)	Speed (kt)		
1800	020	30	996.1	1
1900	020	25	995.8	2
2000	040	20	944.4	2
2100	070	15	994.2	3
2200	050	02	994.2	3
2300	220	05	994.2	3

The above observations indicated that the deep depression lay at 0300 GMT of 10th near Lat. 16.0° N, Long. 85.5° E.

In the evening, *i.e.*, at 1200 GMT ship *ATJV* (17.0 °N, 83.5°E) reported overcast sky with rain and wind 350°/40 kt. An hour later the same ship from Lat. 17.1°N, Long. 83.4°E continued to report 40 kt wind from the north. Though the satellite classification continued to be T-2.5 indicating no further intensification the wind observations showed contrary to it. Also the radar at Visakhapatnam detected spiral banding at 1100 and 1200 GMT. In view of this the system was upgraded to a cyclonic storm at 1200 GMT of 10th centred near Lat. 16.5°N, Long. 84.5°E. The pressure changes (24 hr) along north Andhra coast also became —5 to —8 hpa and the departures —6 to —7 hpa.

Satellite observation of 1500 GMT of 10th, however, indicated further development when the T-classification became 3.0 (45 kt). It continued to be so upto 2300 GMT of 10th. Hourly observations of Visakhapatnam (Table 5) showed that the storm crossed north Andhra coast near Visakhapatnam around 2200 GMT of 10th.

After crossing coast the system retained its intensity over the land for quite some time. The winds at 0.9 km a.s.l. at 0000 GMT of 11th at Visakhapatnam, Machilipatnam and Raipur were 180°/15 kt, 290°/35 kt and 070°/30 kt respectively. Though in the interior land areas the surface winds were not very high but along the coast the onshore winds were moderately high. The 0300 GMT surface winds at Kalingapatnam, Visakhapatnam, Gopalpur and Puri were 170°/15 kt, 210°/15 kt, 090°/20 kt and 160°/15 kt respectively. At 0300 GMT when the cyclonic storm lay centred about 50 km northwest of Visakhapatnam, 5 to 6 closed isobars at an interval of 2 hpa could be drawn. At this hour pressure changes (24 hr) in the area were —5 to —7 hpa and the departures were —6 to —8 hpa.

By evening it weakened into a deep depression and lay centred about 50 km westnorthwest of Jagdalpur. At 1200 GMT the winds at 0.9 km a.s.l. at Raipur, Vishakhapatnam and Jagdalpur were ENE/35 kt, S/30 kt and S/05 kt respectively. Next day morning, *i.e.*, at 0300 GMT on 12th the deep depression lay over Vidarbha and adjoining areas of Telangana and east Madhya Pradesh. From this point the system took a more northerly course than earlier. At this stage it was at the western fringe of the middle and upper tropospheric anticyclones over northeast India and adjoining Burma which in turn steered it northwards. While moving northwards it further weakened and in the evening of 12th lay as a depression over Chindwara in west Madhya Pradesh. At this hour pressure changes (24 hr) and the departures became less significant. By the morning of 13th the system weakened into a low pressure area over west Madhya Pradesh.

After the depression stage the system had almost two days sea travel before crossing the coast. The sea surface temperature of 31°C as reported by ship *ATJV* at 1200 GMT of 9th showed that the sea water was warm in the disturbance area. However, during this period the system developed from T-1.5 stage to T-3.0 stage according to T-classification which is rather slow. The slow development, perhaps, was due to its travel over sea in easterly current along the southern periphery of the upper tropospheric anticyclone.

The system brought a good spell of rainfall over coastal Andhra Pradesh. Telangana and central India. The significant amounts (cm) of rainfall were: Narasapur 21, Koderu 18, Kothagudam 15, Nidadavole & Chintalapudi 12 each, Yollandu 11, Kakinada, Ramagundam & Tuni 10 each on 11th; Nagpur 17, Betul, Nirmal & Sironcha 12 each, Sri Ramsagar 9 on 12th; Kanpur 8, Lucknow 7 on 13th. The storm affected Srikakulam, Vizianagaram, Visakhapatnam, East and West Godavari districts of coastal Andhra Pradesh though the damage caused by it was not significant. Damage to crops and properties was estimated at about Rs. 31 lakhs. As per report heavy rain at Narsapur on 11 October inundated low lying areas in the town due to which 1835 people had to be evacuated.

2.8. *Balasore severe cyclone, 13-17 October*

A cyclonic circulation in the lower and middle tropospheric levels was observed over south China Sea on 11th. Moving westwards it developed into a depression over east central Bay and adjoining north Andaman Sea by the evening of 13th. The disturbance initially moved northwestwards and then northnorthwestwards and intensified into a severe cyclonic storm over northwest Bay on 15th. Thereafter it took a northerly course for next 15 hours and then again a northnorthwesterly course and crossed north Orissa coast near Balasore during early hours of 16th. It dissipated over Bihar plains in the evening of 17th.

TABLE 6

Observations on 15 October

Station/ Ship	Hour of obs. (GMT)	Position		Wind		Pressure (hpa)
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
Paradip	0300	—	—	NNE	30	1000.1
Ship *ATIF*	0300	20.6	88.2	090	30	1001.0
Ship *VTJR*	0000	17.0	87.0	300	50	—
Do.	0300	17.5	87.0	270	45	998.2
Ship *VTDB*	0000	16.2	91.5	190	30	999.0

TABLE 7

Observations at 1200 GMT of 15 October

Ship/Station	Position		Wind		Pressure (hpa)	Present weather
	Lat. (°N)	Long. (°E)	Dir (°)	Speed (kt)		
Ship *ATHK*	28.5	88.4	120	45	991.5	Shower
Ship *VTJR*	18.0	87.1	280	45	998.1	Rain
Sandheads	—	—	NE	15	996.3	Overcast
Chandbali	—	—	NE	10	989.6	Do.
Paradip	—	—	NW	20	994.7	Rain
Puri	—	—	NW	10	996.7	Overcast

At 1200 GMT of 13th Port Blair reported westnorthwesterly wind of 20 kt. It was 270°/25 kt and 260°/25 kt at 0.3 and 0.6 km a.s.l. respectively. INSAT cloud imageries indicated the intensity of the system as T-1.5 (25 kt) at 0900 GMT. The depression lay at 1200 GMT centred near Lat. 13.5°N, Long. 93.0°E.

T-classification of the system became 2.0 (30 kt) on the basis of 0300 GMT INSAT imagery of 14th indicating intensification. At this time the system was declared as a deep depression centred near Lat. 16.0°N, Long. 89.5°E. From 0700 GMT of 14th Cyclone Detection Radar (CDR) at Paradip could detect the spiral banding of the system. But the cloud features as seen in the satellite imageries did not indicate any further intensification. At 1200 GMT of 14th the deep depression lay centred near Lat. 17.5°N, Long. 89.0°E. At this hour ship *VTJR* (18.3 °N, 86.5 °E) and ship *VTDB* (16.9 °N, 91.2 °E) reported winds 040°/08 kt and 210°/16 kt respectively.

HOURLY OBSERVATIONS OF CONTAI & BALASORE FROM 1300 GMT TO 2400 GMT ON 15 OCT. 1985

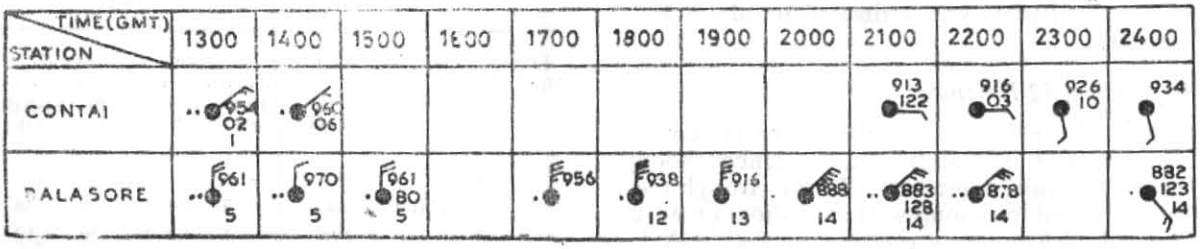

Fig. 3

The satellite classification became T-2.5 (35 kt) at 1500 GMT of 14th and continued to be so upto 0600 GMT of 15th. However, C.D.R., Paradip reported clear 'eye' of the system at 0130 GMT of 15th and continued to detect closed 'eye' upto 0500 GMT. The observations (Table 6) also support that the system had rapidly intensified and became a severe cyclonic storm which lay at 0300 GMT of 15th centred near Lat. 19·5° N, Long. 87.5°E.

Also the pressure changes (24 hr) and the departures along north Orissa coast became —4 to —6 hpa and —8 to —10 hpa respectively. At this time the central pressure of the system was 992 hpa as estimated according to Mishra and Gupta's formula. Moving northwards the severe cyclonic storm lay in the evening centred near Lat. 20.5°N, Long. 87.5° E. At 1200 GMT of 15th CDR, Paradip detected the open 'eye' of the storm but CDR, Calcutta did not observe the eye. Satellite classification for the system became T-3.0 (45 kt) from 0800 GMT and it remained so upto 0000 GMT of 16th. The observations (Table 7) at 1200 GMT of 15th showed the characteristic wind pattern around the storm.

From the above observations it appears that the wind maxima associated with the storm at this hour lay in the rear quadrants.

From the hourly observations of Balasore, Contai, given in Fig. 3, it appears that the storm crossed north Orissa coast, south of Balasore around 2300 GMT of 15th.

The lowest pressure recorded at Balasore was 987.8 hpa at 2200 GMT of this day. 2300 GMT observation for the station was not available.

On crossing coast the system weakened and lay at 0300 GMT of 16th as a cyclonic storm about 30 km westsouthwest of Balasore. At this hour the winds over north coastal Orissa were of the order of 20 to 25 kt from west to southwest and that over coastal West Bengal of the order of 15 to 25 kt from the east. However, Sandheads wind and pressure were S/45 kt and 995.7 hpa respectively. The lowest pressure at this time reported at Balasore was 991.3 hpa. Also ship *ATIF* (20.7°N, 88.3°E) reported wind as 190°/30 kt and ship *ATHK* (20.6°N, 88.8°E) at 0000 GMT as 200°/45 kt. The wind report at 06GMT from the ship *ATIF* (20.9°N, 88.2°E) was 190°/35 kt. In the evening when the system lay centred about 50 km southeast of Jamshedpur, it also retained its storm intensity. The winds along north coastal Orissa and coastal West Bengal continued to be of the order of 15 to 25 kt. However, Chandbali wind was SSE/30 kt. The ship *ATIF* (20.8°N, 88.1°E) at 1400 GMT reported 30 kt wind from SSW. On this day pressure departures and changes (24 hr) in the storm field were —9 to —14 hpa and—4 to —8 hpa respectively.

By 17th morning it weakened into a deep depression over Bihar Plateau centred about 40 km north of Hazaribagh. Moving further north, it weakened into a well marked low pressure area over Bihar plains by evening.

Under the influence of the system there was heavy to very heavy rainfall on a couple of days in several places of West Bengal & Sikkim, Orissa and Bihar. The significant amounts (cm) of rainfall were : Daitary 19, Bhubaneswar AP 8 on 15th; Akhuapada 35, Bonth 23, Jenapur 22, Keonjhargarh 20, Anandpur 19, Swampatna 18, Jeypore 17, Champua, Kamakhyanagar & Joshipur 15 each, Balasore & Udala 14 each, Rajghat 13, Cuttack & Thakurmunda 12 each, Midnapore, Sandheads, Paradip, Baripada & Karanjia 11 each, Contai, Digha & Purulia 8 each on 16th; Dhanbad 13, Muzaffarpur & Champua 12 each, Swampatna 11, Patna & Anandpur 10 each, Ranchi, Bhagalpur & Karanjia 9 each, Kalimpong, Darjeeling, Purulia & Hazaribagh 8 each on 17th; Baghdogra 18, Darjeeling 15, Muzaffarpur 11, Tadong & Kalimpong 10 each, Patna AP, Supaul & Gangtok 9 each on 18th.

According to reports 13 persons lost their lives in Midnapore, 24-Paraganas and Darjeeling districts of West Bengal and 47 in Cuttack, Balasore and Keonjhar districts of Orissa. Also 38 persons were reported missing in the above mentioned districts of Orissa. 1570 cattle heads perished in West Bengal and 1073 in Orissa. Crops in 72,000 hectares in 1204 villages of Midnapore and 24-Parganas and 3,24,795 hectares in 8509 villages of Cuttack, Balasore, Keonjhar, Dhenkanal and Mayurbhanj districts were affected. 30, 966 houses collapsed in West Bengal and 8703 in Orissa. Population of about 7.6 lakhs was affected by the storm in West Bengal. In Balasore district saline inundation of some low lying coastal areas damaged standing crops. Tidal wave of 1.5 m to 2 m high above normal tide was also reported in the area. High winds snapped electric wires in several places in the district. Sagar, and Gasaba islands of 24-Parganas in West Bengal were worst affected while Kakdweep which is on the other side of Sagar Island, was not much affected. Winds of 70 to 100 kmph in gusts blew over these islands. Major irrigation installations in Sagar, Pathar Pratima, Basanti and Namkhana were breached. Tidal waves of 3 to 3.5 metres high were reported from these islands and about

2 metres high from coastal areas of Contai sub-division. The damage to crops and public utilities in Midnapore and 24-Parganas districts was estimated to about Rs. 15.1357 crores.

2.9. *Depression, 12 November*

Preceding the formation of the depression the equatorial trough over southwest Bay and neighbourhood became active for quite some time. In this trough the depression developed over southwest and adjoining west central Bay on 12th morning centred at 0300 GMT near Lat. 12.5° N, Long. 81.0° E. At 0000 GMT of this day the winds at 0.9 km a.s.l. at Madras and Karaikal were ENE/35 kt and NW/20 kt respectively. Ship *SPUJ* (12.4°N, 80.2°E) reported at 0500 GMT squally winds of 50 kt from the west, and at 0600 GMT 230°/35 kt from the vicinity of the above position. CDR, Karaikal also detected intense convection in the area. Satellite imagery of 0300 GMT showed the clouding more to the west of the pressure centre of the system. Moving westwards it lay in the evening centred very close to the coast about 40 km south of Tambaram. 1200 GMT INSAT imagery showed the cloud mass over Tamil Nadu, *i.e.*, the cloud mass associated with the system lay to the west of its pressure centre. From 1800 GMT of 12th the cloud organisation of the system appeared to have been disorganised. By next day morning the system weakened over the sea and subsequently diffused over southwest Bay.

In association with the system heavy to very heavy falls occurred in coastal Tamil Nadu and south Andhra Pradesh on 12th and 13th. The significant amounts (cm) of rainfall were : Madras & Tambaram 30 each, Ponneri 16, Nellore 12 on 12th; Madras 33, Ponneri 30, Kancheepuram 28, Sriperumbudur 24, Tiruthani 20, Tiruvallur 19, Sullurpet 18, Nellore 12, Chittor 11, Ambur & Tirupati AP 10 each, Kaveli 9 on 13th. As per press reports about 50,000 huts were damaged in low lying areas of Madras city due to rain and floods. River *Adyar* in south Madras was in floods at Kotturpuram, where flood waters entered the ground floors of the buildings.

2.10. *Bay cyclonic storm, 15-17 November*

Even after the dissipation of the Bay depression on 13 November, the trough in the lower tropospheric levels over south Bay remained prominent. In this trough a depression developed over south and adjoining west central Bay on 15th. Moving west to westnorthwestwards it intensified into cyclonic storm in the evening of 16th. It moved westnorthwest/northwestwards till 17th evening and then northnortheastwards and dissipated over the waters of west central Bay on 18th.

On the basis of INSAT imagery of 0300 GMT of 15th the system could be classified as T-2.0 (30 kt). On the basis of this observation, the system over south and adjoining west central Bay was declared as depression centred near Lat. 13.0°N, Long. 86.0°E. The subsequent satellite imageries did not show further development upto 1100 GMT of 16th. Table 8 given hereunder has been prepared taking into account all ship observations in the field of the system during its life span. However, 0600 GMT observation from the ship

TABLE 8

Ship observation, 15-17 November

Date (Nov' 85)	Call sign of the ship	Hour of obsn. (GMT)	Position		Wind		Sea surface Temp. (°C)
			Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
15	VNHE	0600	12.5	81.5	330	24	30.0
	VTTX	1200	13.1	84.7	320	13	28.0
	VTFY	Do.	14.0	82.9	020	17	—
16	VTFY	0300	10.2	82.4	300	10	—
	SZLW	0400	12.5	85.8	180	19	—
	YTTX	0600	9.5	83.4	270	23	31.0
	SZLW	1200	15.6	87.8	170	20	28.0
17	ATJY	0600	13.5	81.1	300	20	
	ATFG	0600	13.6	85.4	170	26	

VNHE (Table 8) indicated the intensity of the system higher than that of a depression. It was declared as a deep depression at 1200 GMT of 15th centred near Lat. 13.5°N, Long. 85.5°E. The deep depression took westerly course and intensified into a cyclonic storm by 1200 GMT of 16th, when it lay centred near Lat. 13.5°N, Long. 84.0° E. At this time the T-classification of the system became 2.5 (35 kt), which continued to remain as such upto 0100 GMT of 17th. Moving westnorthwestwards the storm lay centred at 0300 GMT of 17th near Lat. 14.0°N, Long. 82.5°E. Pressure departures and changes (24 hr) along north Tamil Nadu-south Andhra coast did not show at 0300 GMT either significant negative anomaly or fall. While moving northwestwards from this point the system started weakening and at 1200 GMT satellite imagery of INSAT-1B indicated its intensity as T-1.5 (25 kt). At this time the system lay as a depression centred near Lat. 15.0° N, Long. 81.5° E. Thereafter, it moved northeastwards and further weakened into a low pressure area over west central Bay by next day morning.

Curiously enough when the storm approached north Tamil Nadu-south Andhra coast, a vortex in the lower and middle tropospheric levels was established over the southeast and adjoining east central Arabian Sea and became prominent at the time of the weakening of the storm. The system did not cause adverse weather over the Indian sub-continent.

2.11. *Sriharikota cyclone, 11-14 December*

A well marked low pressure area was observed over southeast Bay in the morning of 11th which concentrated into a depression by 0600 GMT. It moved initially in a westerly direction and then in a northwesterly direction and intensified into a cyclonic storm by 0600 GMT of 12th. Continuing to move northwestwards it crossed south Andhra coast at Sriharikota around 1800 GMT of 13th and dissipated over Rayalaseema by 14th evening.

In the morning of 11th convective cloud cluster was observed over southeast Bay in the satellite imagery and also the 0000 GMT observation of the ship *ATUG* (5.7° N, 86.7° E) reported 5 kt wind from north and

TABLE 9

Ship observation on 12 December

Call sign of the ship	hour of obsn. (GMT)	Position		Wind		Remarks
		Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
ATQP	0000	5.7	87.2	300	12	Drizzle
JFJK	0600	5.7	80.5	250	15	SST 27.0°C
VTKL	0600	11.1	83.6	020	23	Overcast sky
VTKL	1200	9.7	83.4	310	30	Overcast sky and raining
VWDG	1200	12.5	86.6	090	20	Overcast sky
ATML	1200	12.6	84.4	070	12	—
ATDV	1200	12.2	80.7	360	20	Overcast sky

TABLE 10

Ship observation at 1200 GMT of 13th

Call sign of the ship	Position		Wind		Remarks
	Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kt)	
ATDV	13.1	80.5	360	40	Raining
ATLF	14.3	81.4	050	25	Drizzling
VWDG	13.0	83.0	120	20	Overcast

TABLE 11

Sriharikota observations

Date and hour of obsn. (GMT)	Pressure (hpa)	Wind		Pressure change for past 24-hr (hpa)
		Dir. (°)	Speed (kt)	
13/1700	1001.5	010 gusting to 62 kt	54	—8.4
13/1800	1001.5	70 gusting to 12 kt	08	—10.9
13/2000	1005.2	110	14	—6.0
13/2200	1005.4	170	02	—5.0

overcast sky with 6 oktas cumulus cloud. On the basis of 0600 GMT INSAT imagery the system could be classified as T-1.5 (25 kt). At 1200 GMT the satellite classification became T-2.0 (30 kt) when the depression lay centred near Lat. 8.0°N, Long. 88.0°E. Ship's observation from the depression field was absent.

On 12th from the vicinity and from around the depression a few ship observations, which are listed (Table 9), indicated the intensification of the system. On the basis of INSAT imageries the system could be classified as T-2.0 (30 kt) at 0300 GMT of 12th, which became T-3.0 (45 kt) at 0900 GMT and remained as such upto 2300 GMT of 13th.

At 0300 GMT of 12th when the depression lay centred near Lat. 8.5°N, Long. 87.0°E, the ship observations of *ATQP* and *JFJK* indicated the strengthening of westerlies over south Bay. At 1200 GMT when the system intensified into a cyclonic storm and lay centred near Lat. 10.0°N, Long. 84.5°E, the observation of the ship *VTKL* was relevant.

On 13th morning the cyclonic storm lay centred near Lat. 11.5°N, Long. 82.5°E. At 0000 GMT ship *VWDG* (12.7°N, 84.7°E) reported wind 130°/20 kt. The pressure changes (24 hr) along Tamil Nadu coast at 0300 GMT were of the order of —2 to —3 hpa only. At 1200 GMT the storm lay closer to north Tamil Nadu coast with its centre near Lat. 13.0°N, Long. 81.0°E. Cyclone Detection Radars (CDR) at Madras and Karaikal spotted the storm centre with spiral banding overlay. The ship observations (Table 10) were also available from the storm field.

At this hour Madras reported 25 kt wind from the north and Tambaram 20 kt wind from northnorthwest. The central pressure, estimated as per Mishra and Gupta's formula was 996 hpa. The pressure change and departure at Madras were —4.6 hpa and —6.1 hpa respectively. CDR, Madras located the 'open eye' of the system for the first time at 1600 GMT of 13th. Just before crossing Sriharikota, the storm intensity probably reached in the threshold of a severe cyclonic storm.

The observations from Sriharikota (Table 11) indicate that the storm crossed near Sriharikota around 1800 GMT of 13th.

As per touring officers report the lowest station level pressure at Sriharikota was 998 hpa at 1728 GMT (2258 IST) of 13th. The pressure at the station started falling at the rate of 2.5 hpa per hour between 1600 GMT and 1800 GMT of 13th and later showed sharp increase. Strong gale force winds prevailed over the station between 1600 GMT & 1730 GMT, mainly from the north and later light to moderate winds from the southeast. The peak wind speed was 128 kmph in gust.

At 0300 GMT of 14th, the storm lay as a depression over south Andhra Pradesh and adjoining north Tamil Nadu centred about 50 km southwest of Nellore. By evening of the same day it weakened into a low pressure area over Rayalaseema of Andhra Pradesh.

The system very rapidly grew from T-2.0 at 0300 GMT to T-3.0 at 0900 GMT of 12th. The system moved along the western periphery of the upper tropospheric anticyclone over Indo-China.

The system caused heavy to very heavy rainfall on a couple of days in south Andhra Pradesh. Significant amounts (cm) of rainfall in association with the

TABLE 12

Rainfall (mm) from 13 to 15 December 1985 in Nellore district

Station	13th	14th	15th	Total
Atmakur	11.2	80.0	19.6	110.8
Gudur	0.0	93.0	16.0	109.0
Kavali	6.4	155.0	35.4	196.8
Kovur	0.0	188.4	4.0	192.4
Nayudupet	6.3	37.2	0.0	43.5
Nellore	0.0	131.0	10.0	141.0
Podalakur	6.3	76.3	5.2	87.8
Rapur	11.2	50.8	6.8	68.8
Sullurpet	6.6	42.0	0.0	48.8
Udayagiri	4.8	34.0	42.5	81.3
Venketagiri	4.6	43.8	6.2	54.6

system were : Kovur 19, Kaveli 15, Nellore 13, Gudur 9, Machilipatnam, Ongole, Bapatla, Avanigadda, Atmakur and Podalakur 8 each, Guntur 7 on 14th; Podili 9, Narsapur & Markapur 8 each on 15th.

Cumulative rainfall analysis in Nellore district from 13 to 15 December 1985 is given in Fig. 2 and Table 12.

12 persons reported to have been killed and four villages were cut off due to floods in *Swarnamukhi* river and Mandi canal in Nellore district. It uprooted a few electric and telegraph poles.

3. Arabian Sea

3.1. *Cyclonic storm, 28-30 May*

A low pressure area, which developed over east central and adjoining west central Arabian Sea on 27th evening, concentrated into a depression over east central Arabian Sea by 28th morning and lay centred at 0300 GMT near Lat. 15.0°N, Long. 67.0°E. Moving in a northerly direction it intensified into a cyclonic storm by the evening of 29th. Continuing its northward journey it dissipated over northeast Arabian Sea by the morning of 31st.

On 28th morning the winds over central Arabian Sea were strong as evident from the observations in Table 13.

At 0300 GMT of 28th the system had a T-classification of 1.5 (25 kt). By evening it intensified into a deep depression centred near Lat. 16.5°N, Long. 67.0°E when satellite observation indicated its intensity as T-2.0 (30 kt). Ship *ATJE* (16.8°N, 68.3°E) reported wind SSE/25kt. Also, the winds along the west coast at 0.9 km a.s.l. strengthened. They were SSW/35 kt at Panjim, S/30 kt at Ratnagiri and Bombay. After 1200 GMT of 28th there was no further development till 0500 GMT of next day.

TABLE 13

Ship observation on 28 May

Call sign of the ship	hour of obsn. (GMT)	Position		Wind	
		Lat. (°N)	Long. (°E)	Dir. ( )	Speed (kt)
FNOV	0000	12.6	72.2	190	30
PCOM	0600	12.7	71.9	200	40
SHIP	0600	15.5	70.5	230	25
ATUY	0600	16.5	62.9	290	19

At 0300 GMT of 29th, the deep depression lay centred near Lat. 17.5°N, Long. 67.5°E. At this hour a ship (18.6°N,66.6°E) reported wind as 070°/25 kt. As per satellite classification the system started intensifying after 0300 GMT. The T-classification became 2.5 (35 kt) at 0500 GMT and 3.0 (45 kt) at 1200 GMT of 29th. At 0600 GMT ship *Vishwasobha* (17.6°N, 67.2°E) and at 0900 GMT ship *DATKRD* (16.0°N, 69.0°E) reported winds as N/45 kt and SW/40 kt respectively. The deep depression intensified into a cyclonic storm and lay at 1200 GMT centred near Lat. 18.0°N, Long. 68.0°E.

Moving further north the storm lay at 0300 GMT of 30th centred near Lat. 20.0°N, Long. 68.0°E. Satellite classification continued to be T-3.0 at this hour. Though it was about 200 km away from the Saurashtra coast, it did not cause high winds along the coastal areas except southerly wind of 15 kt at Veraval. However, the pressure departures along Saurashtra coast were about—6 hpa at 0300/30th. Later satellite imageries showed weakening of cloud organisation. It could be classified as T-2.5 on the basis of 0500 GMT imagery, which continued to be so at 1200 GMT when the cyclonic storm lay centred near Lat. 21.5°N, Long. 67.5°E. At this hour surface winds at Veraval, Porbandar and Naliya were S/15 kt, SSW/20 kt and SSE/15 kt respectively. Pressure departures along Saurashtra and Kutch coast were -4 to -6 hpa.

Thereafter the system showed rapid decaying. It weakened into a low pressure area over northeast Arabian Sea by next day morning.

The system moved along the western periphery of mid-tropospheric levels anticyclone over central India and neighbourhood.

The system helped in advancing southwest monsoon along west coast upto coastal Karnataka.

3.2. *Depression, 6-9 October*

The low pressure area which lay over south Andhra Pradesh on 2nd evening (remnant of the Bay depression which crossed south Andhra coast near Ongole on 2nd forenoon) moved westnorthwestwards and emerged into east central Arabian Sea on 5th.

On 6th, it concentrated into a depression over east central and adjoining northeast Arabian Sea and lay

centred at 0300 GMT near Lat. 19.5°N, Long. 71.5°E. At this time ONGC rig ship *Sagar Samrat* (19.2°N, 72.0°E) reported S/18 kt winds. Another ship *Sagar Jyoti* (18.4°N, 72.3°E) reported wind as 030°/20 kt. Wind at 0.9 km a.s.l. at Bombay was SE/30 kt. Pressure departures along north Maharashtra-south Gujarat coast were of the order of —4 to —6 hpa, but the pressure changes were positive. Satellite observation classified the system as T-1.5 (25 kt) at 0900 GMT and continued the same classification upto 2100 GMT. Moving northwards the system lay at 1200 GMT of 6th centred near 20.0°N, 71.5°E. At this time though pressure departures along Gujarat-north Maharashtra coasts continued to be negative, the pressure changes (24 hr) were still positive.

Continuing to move nortwards the depression crossed Saurashtra coast near Mahuva in the early hours of 7th and lay at 0300 GMT about 40 km west of Bhavnagar. At this time the pressure changes were negative over Saurashtra and were of the order of 3 to 4 hpa. The system took an anticlockwise loop over Saurashtra on this day and lay at 0300 GMT of 8th over the sea about 60 km northwest of Dahanu. Pressure changes and departures in the depression field were —3 to —4 hpa and —8 to —11 hpa respectively. However, the surface wind was light in the area. Thereafter recurving northeastwards it crossed south Gujarat coast south of Bulsar in the forenoon and lay in the evening over southwest Madhya Pradesh and neighbourhood centred about 80 km (21.5°N, 75.0°E) northwest of Jalgaon. Surface winds in the coastal areas of Gujarat State strengthened and became about 15 kt blowing from the north. Continuing to move northeastwards it lay over northwest Madhya Pradesh and neighbourhood on 9th morning centred at 0300 GMT about 80 km northwest of Bhopal. Surface winds over northwest Madhya Pradesh and neighbourhood were 02 to 05 kt. only. Also the vertical extension of the circulation associated with the depression decreased and extended only in the lower tropospheric level. Thereafter the system rapidly weakened and lay in the evening as a low pressure area over northwest Madhya Pradesh and neighbourhood.

Under the influence of the system monsoon became vigorous on 1 to 4 days in Konkan and Goa and Marathwada. Generally widespread rain with isolated heavy to very heavy falls occurred on 1 to 2 days in plains of west Uttar Pradesh, Punjab, Himachal Pradesh, Jammu & Kshmir, east Rajastan, west Madhya Pradesh and Gujarat State. The significant amounts (cm) of rainfall were: Bhavnagar 16, Ambone & Dungarwadi 10 each, Jalna, Bhira, Ashti & Rawat Bhata 8 each on 6th; Idar 16, Ahmedabad 9, Sawaimadhopur 8 on 7th, V.V.Nagar 21, Baroda city 18, Ahmedabad 17, Vengurla 13, Devgarh 12, Goa (Dabolim) 10, Dohad & Maihar 9 each, Idar & Bhavnagar 8 each on 8th; Guna 27, Ratlam 19, Indore 16, Pathankot 13, Mandsaur 12, Panjim 11, Gurdaspur, Nurpur, Kangra & Kathua 10 each, Jhansi & Amritsar 9 each, Katra, Jogindernagar, Shivpuri & Tikamgarh 8 each on 9th, Lucknow AP 20, Kandaghat 13, Nahan, Dharampur & Kangra 11 each, Rajgarh, Dharamsala & Kanpur 9 each, Fatehabad 8 on 10th.

According to reports the heavy rain in Gujarat, which was facing acute shortage of drinking water was welcomed. However, heavy rains claimed 13 lives in the State.

4. Land depressions

4.1. *Depression, 5-6 August*

The remnant of the 1 August Bay depression lay as a low pressure area over central parts of Rajasthan on 4th. It moved northwards along the western periphery of the upper tropospheric Tibetan anticyclone. Under the influence of a middle and upper tropospheric trough in westerlies it concentrated into a depression by 5th morning over northwest Rajasthan and neighbourhood and lay centred at 0300 GMT about 80 km eastsoutheast of Gnaganagar. The pressure changes for past 24-hr recorded on this morning over northwest Rajasthan and adjoining Punjab and Haryana were of the order of—3 to —4 hpa and the departures over northwest Rajasthan and adjoining Haryana were also of the same order. Moving northeastwards it lay at 1200 GMT of 5th centred close to but southeast of Bhatinda. It, then, moved northwards and lay over Punjab and neighbourhood on 6th morning centred at 0300 GMT about 50 km southwest of Halwara. Satellite cloud pictures of INSAT-1B showed weakening and disorganisation of the system from 5th,12 00 GMT onwards. But on 6th morning, the pressure changes for past 24-hr in the area were —3 to —4 hpa and the departures were —3 to —6 hpa. By evening, the system weakened into a low pressure area over Punjab and adjoining north Pakistan. Under its influence monsoon was active to vigorous over Haryana and Punjab from 5th to 7th and was so on 5th and 7th over plains of west Uttar Pradesh and Jammu & Kashmir and on 6th over hills of west Uttar Pradesh. Significant amounts (cm) of rainfall were : Hissar 22, Bhatinda 11, Jind & Dhuri 10 each, Jagraon & Malerkotla 8 each on 5th ; Bijnore 37, Malerkotla 19, Tarabganj & Nagina 16 each, Jagraon 12, Hardwar 11, Ferozepur 9, Ludhiana 8,

Jind 7 on 6th; Lasuya 11, Raya, Lalitpur & Bijnore 10 each, Ambala 8, Amritsar, Hoshiarpur & Gurdaspur 7 each on 7th. Rivers *Banganga* and *Ghambiri* in Rajasthan were in floods marooning 46 villages.

4.2. *Depression, 23-24 September*

The second land depression of the year formed when the remnant of the Bay cyclonic storm which lay over Madhya Pradesh, concentrated into a depression over northwest Madhya Pradesh and neighbourhood on 23rd morning centred just north of Guna. At 0300 GMT 3 closed isobars at an interval of 2 hpa could be drawn and Guna reported lowest pressure of 1001.3 hpa and light westerly wind. Pressure departures over a small area of northwest Madhya Pradesh were —3 to —6 hpa. Satellite observations also showed vortex cloud over northwest Madhya Pradesh and neighbourhood. The system remained practically stationary there till evening. Thereafter under the influence of mid and upper tropospheric westerlies it moved northnortheastwards and lay by 24th morning about 50 km northeast of Gwalior. Pressure departures at 0300 GMT in the depression field were —3 to —5 hpa. At this time Gwalior reported lowest pressrue of 1000.8 hpa and northwesterly 5 kt wind. By evening it lay over southwest Uttar Pradesh and neighbour hood centred close to but southwest of Mainpuri. At this time the pressure changes (24-hr) in the area were insignificant indicating weakening/filling up of the system. Continuing to move northnortheastwards it weakened over plains of west Uttar Pradesh and adjoining east Uttar Pradesh by 25th morning and became unimportant over northeast Uttar Pradesh on 26th.

Under the influence of the system monsoon became active to vigorous on 2 to 3 days in east Uttar Pradesh and west Madhya Pradesh. Generally widespread rainfall occurred on 1 to 2 days in plains of west Uttar Pradesh, Haryana, Himachal Pradesh, Jammu & Kashmir and east Rajasthan. Significant amounts (cm) of rainfall were: Lateri 21, Shajapur 18, Raisen 13, Tarana & Bhopal 12 each on 23rd; Guna 23; Lateri & Tarana 12 each, Shajapur 10, Bahraich 9, Ranchi AP 7 on 24th; Lucknow AP 14, Zaheerabad 11, Gorakhpur AP 8, Kanpur AP & Raigarh 7 each on 25th.