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Cyclones and depressions over the Indian seas in 1980

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1. Chief features

During 1980 the cyclonic storm activity in the Indian seas was subnormal. Only three cyclonic storms developed in the Bay of Bengal and all of them were minimal storms. No storm developed in the Arabian Sea. The last time when only 3 cyclonic storms formed in the Indian seas in a year was in 1957. In all the subsequent years at least five storms have formed.

In the pre-monsoon season, there was no cyclonic storm. One depression developed in the Bay of Bengal in May and moved away towards Burma coast.

In the monsoon season there were seven depressions. The interesting features were that four out of seven depressions developed over land and most of the depressions had short life periods of about 2 days or less. July was completely devoid of depressions. Out of the three depressions which formed over the sea, one was in the Arabian Sea and two were in the Bay of Bengal.

In the post-monsoon season, there were three storms and three depressions. All the three storms developed in the Bay of Bengal. These storms were weak with about 40 kt winds in circulation and none of them crossed the coast as a storm. Hence no damage to life or property was reported in association with these storms.

The tracks of these systems are shown in Fig. 1 and their listing in Table 1. The maximum wind and lowest mean sea level pressure associated with the cyclonic storms are given in Table 2.

The salient features of the various disturbances are discussed below :

2. Bay of Bengal

2.1. *Depression of 15-19 May*

A low which lay over central parts of south Bay on 13th moved slowly northwards and concentrated into a depression on the morning of 15th with its centre near 12.0 deg. N, 86.5 deg. E. This system was declared a depression at this location based mainly on satellite pictures which showed that the system could be classified as T 2.0 or 2.5 in Dvorak's scale. No ships' reports were available on this day near the depression field. The low level winds of Port Blair were W/SW 20-25 kt on this day. Recurving northeastwards and later moving eastwards the depression weakened into a low over Tenasserim coast by 19th evening. The low persisted there till 22nd and moved into central Burma and adjoining Thailand later.

This system caused generally widespread rain or thundershowers in Andaman and Nicobar Islands from 16th to 22nd with some heavy to very heavy falls on many days. The notable amounts of heavy rainfall (cm) were : Port Blair 11 on 17th; Long Island 19, Port Blair 13, Nancowry, Maya Bandar 12 each on 18th; Maya Bandar 16, Car Nicobar 10 on 19th; Port Blair 14 on 21st; Hut Bay 12 on 22nd. Under the influence of this system, the southwest monsoon advanced into south Andaman Sea and adjoining southeast Bay on 20th and into north Andaman Sea on 21st.

2.2. *Depression of 26 August*

A low pressure wave moved westwards across north Burma into northeast Bay by 25th evening and concentrated into a depression over northeast Bay and adjoining Bangla Desh on the

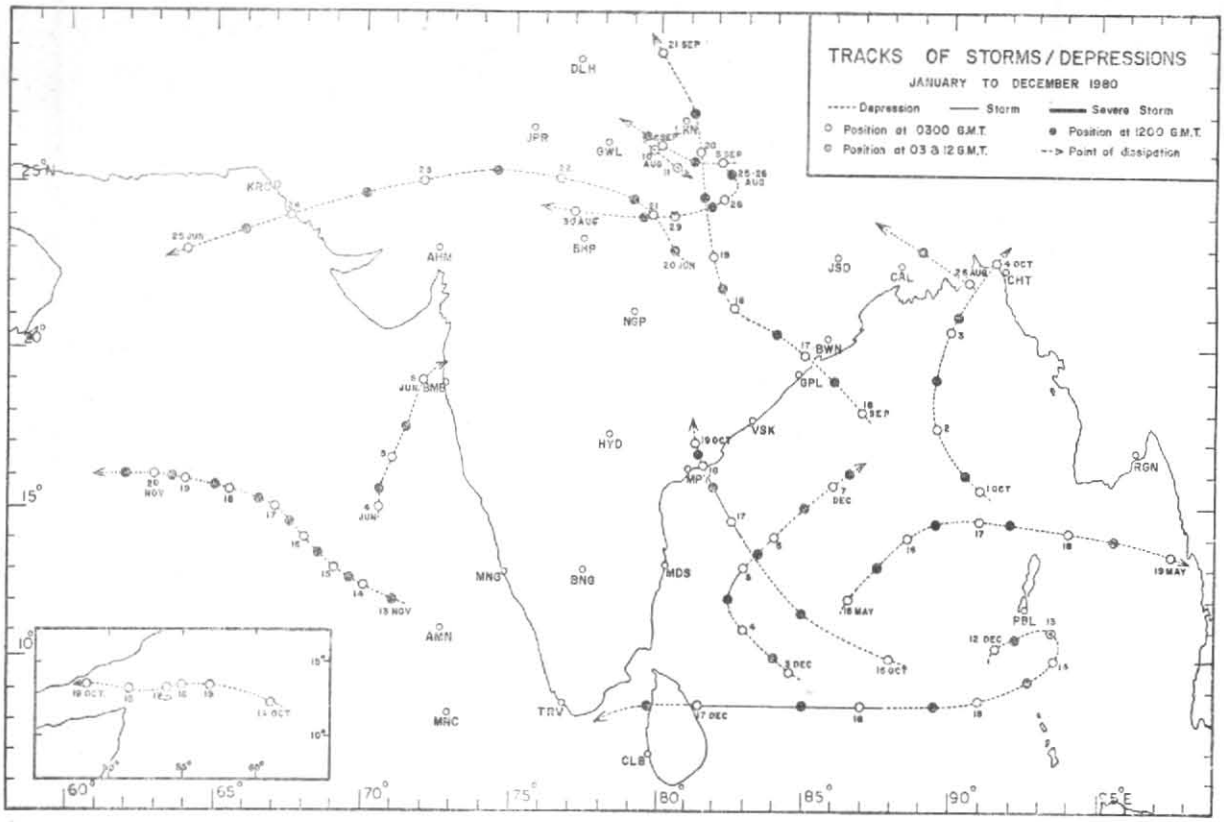

Fig. 1. Tracks of storms and depressions of 1980

TABLE 1

Storms and depressions of 1980

S. No.	Type of disturbance	Life Period	Location
1	Depression	15 – 19 May	Bay of Bengal
2	Do.	4 – 6 Jun	Arabian Sea
3	Do.	20 – 25 Jun	Land
4	Do.	10 – 11 Aug	Do.
5	Do.	25 – 30 Aug	Do.
6	Do.	26 Aug	Bay of Bengal
7	Do.	5 – 6 Sep	Land
8	Deep Depression	16 – 21 Sep	Bay of Bengal
9	Depression	1 – 4 Oct	Do.
10	Cyclonic Storm	16 – 19 Oct	Do.
11	Deep Depression	14 – 19 Oct	Arabian Sea
12	Do.	13 – 20 Nov	Do.
13	Cyclonic Storm	3 – 7 Dec	Bay of Bengal
14	Do.	12 – 17 Dec	Do.

TABLE 2

Maximum wind and minimum pressure in cyclones

Cyclonic storm (Date)	Max. wind (kt)		Lowest MSL Pressure (mb)	
	Estimated form sat. pictures or other sources	Reported form nearest obsn.	Estimated at the centre	Reported from nearest obsn.
16 – 19 Oct	40	45 (*ONGC* ship Frederiksburg 100 km north of storm centre)	996	997.4 (at Masulipatnam)
3 – 7 Dec	40	25 (Ship *VWCK* and ship *GVAM* 300 km to SW and SE of storm centre)	998	—
12 – 17 Dec	40	30 (Ship *VWWT* 150 km from storm centre on 16 and at Trincomalee on 17)	998	1001.0 (at Trincomalee)

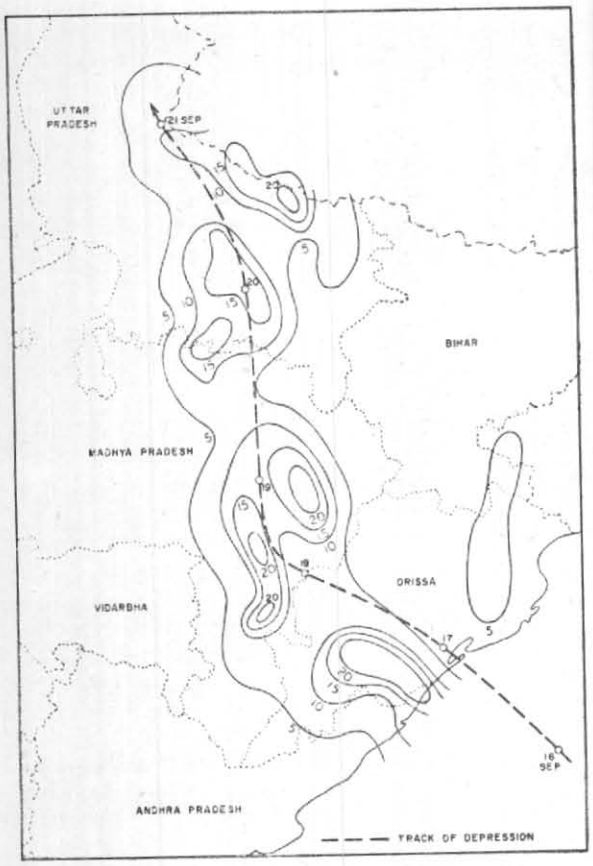

Fig. 2. Heaviest 24 hour rainfall (cm) along and near the track of the depression during the period 17–21 September 1980

morning of 26th with its centre at 0300 GMT near 22.0 deg. N, 90.5 deg. E. It moved northwestwards and weakened into a low over the eastern parts of Bihar by 27th morning.

This system caused generally widespread rain in Gangetic West Bengal, Orissa and Bihar Plateau on 26th and 27th with isolated heavy falls in Orissa on these two days and a few heavy to very heavy falls in Gangetic West Bengal and adjoining Bihar Plateau on 27th. The significant amounts of heavy rainfall (cm) were: Dhanbad 22, Sriniketan 14, Magra 13 and Calcutta (Alipore) 11 on 27th.

The pressure departure from normal near the centre of the depression was *minus* 7 to 8 mb. Dacca reported upper winds ENE/25 kt and Chittagong ESE/25 kt at 0000 GMT on 26th at 0.9 km asl. The same evening Jessore reported SW/S 30 kt and Agartala SE/30-40 kt up to 0.9 km asl. Sandheads reported surface wind SW/W 25-30 kt on 26th morning and evening. On the basis of these observations, the system was classified as a depression.

2.3. *Deep depression of 16-21 September*

A low which was over west central and adjoining northwest Bay on 15th concentrated into a depression on the morning of 16th with its centre at 0300 GMT near 18.0 deg. N, 87.0 deg. E. Moving northwestwards, it became deep on 17th morning close to Orissa coast. Continuing to move northwestwards as a deep depression across Orissa and later northwards across east Madhya Pradesh and east Uttar Pradesh, it weakened into a depression by 21st morning and broke up over Nepal Himalayas and adjoining hills of Uttar Pradesh by noon the same day.

In association with this depression, generally widespread rain occurred in Orissa and Gangetic West Bengal from 16th to 18th, in east Madhya Pradesh from 18th to 20th and in Uttar Pradesh on 20th and 21st. Srikakulam district of coastal Andhra Pradesh also experienced very heavy rain on 17th. The notable amounts of heavy rainfall (cm) were: Bessam Cuttack 22, R. Udayagiri (Orissa), Sompeta (Andhra Pradesh) 20 each, Tandur (Andhra Pradesh) 15, Kalingapatnam 12, Koraput, Cheepurupalli (Andhra Pradesh), Tekkali (Andhra Pradesh) 10 each on 17th; Bhawanipatna 22, Kanker 20, Komna (Orissa) 16, Gudari (Orissa) 11 on 18th; Karera (Madhya Pradesh) 26, Raipur 20, Champa 19, Mungeli, Ajaigarh (Madhya Pradesh) 15 each, Pendra 14, Bilaspur 13 on 19th; Fatehpur 17, Lucknow 16, Allahabad 14, Chillaghat (Uttar Pradesh), Khaga (Uttar Pradesh) 13 each, Unnao 11, Bansgaon (Uttar Pradesh) 10 on 20th; Balrampur (Uttar Pradesh) 34, Utraula (Uttar Pradesh) 19, Bahraich, Kakardari (Uttar Pradesh) 15 each; Kanpur 11, Kheri, Pilibhit, Sardanagar 10 each on 21st. A map showing the heaviest rainfall recorded along and close to the depression track during its life period is shown in Fig. 2.

According to press reports and *'Weekly Flood News Letter'* of the Central Water Commission heavy rain in Orissa, extreme north coastal Andhra Pradesh and east Madhya Pradesh caused flash floods in the Vsmsadhara and the Mahanadi leading to loss of life and property in Srikakulam district of Andhra Pradesh and Koraput, Ganjam, Puri and Cuttack districts of Orissa. Gunupur, Gudari and Kashinagar towns in Orissa were the worst affected. About 200 persons in Orissa and about 60 persons in Andhra Pradesh were reported to have lost their lives. About 6000 cattle perished in Orissa and about 3000 in Andhra Pradesh. About 30,000 houses/huts were damaged in Andhra Pradesh. Serious damage was caused to railway tracks in Srikakulam district. Heavy rain in east Madhya Pradesh inundated low lying areas in some parts of Bilaspur and Raipur divisions and dislocated road communications. Heavy rain

TABLE 3

Deep depression of 16 – 21 September 1980

Date	Time (GMT)	Ship/Station	Appr. distance from storm centre (km)	Wind		Pressure (mb)
				Direction	Speed (kt)	
16	00	Bhubaneswar		NE (at 0.6 & 0.9 km asl)	30	
	00	Gopalpur		NNE (at 0.6 & 0.9 km asl)	25	
	06	ATJR (17.1°N, 86.6°E)	150	W	25	1001.2
	12	ATJR (18.5°N, 87.4°E)	175	S	20	1001.3
	12	ATMS (17.2°N, 84.7°E)	250	SW	25	1002.0
17	00	Puri		SE	30	998.3
	00	ATNN (20.2°N, 87.0°E)	200	SSE	28	1000.0
	00	Bhubaneswar		ESE (at 0.6 & 0.9 km asl)	40	—
	06	Gopalpur		SW	30	998.9
	12	Bhubaneswar		S (at 0.6 & 0.9 km asl)	25	
	12	Raipur		NNW (at 0.9 km asl)	25	
18	06	Allahabad		E (at 0.6 & 0.9 km als)	30	
19	00	Allahabad		E (upto 0.9 km asl)	35-45	
	12	Allahabad		NE-E (at 0.6 & 0.9 km asl)	40	
	12	Gorakhpur		ENE-E (at 0.6 & 0.9 km asl)	35-40	
	18	Allahabad		E	25 (gusty)	993.5
	18	Varanasi A.P.		ESE	32	998.7
20	00	Allahabad		S	40 (gusty)	993.7
	00	Lucknow		NE-E (upto 0.9 km asl)	40-45	
	03	Allahabad A.P.		S	40 (gusty)	997.6
	12	Lucknow		NW	25	996.7
	12	Gorakhpur		S (upto 0.9 km asl)	25	
	12	Allahabad		W (at 0.6 & 0.9 km asl)	25-30	

in east Uttar Pradesh caused many house-collapses and worsened the flood situation in that State. About 75 people were reported to have perished mainly due to house-collapses in this spell of heavy rain in Uttar Pradesh. Generally 4 to 5 closed isobars at 2 mb interval covered the depression field from 17th to 20th. On the morning of 19th, six closed isobars covered the depression field and the highest pressure departure of *minus* 12 mb from normal was reported near the depression centre on this morning at 0300 GMT. Some important reports from observatories and ships in the depression field are given in Table 3.

2.4. *Depression of 1-4 October*

A low pressure area moved across Tenasserim coast into north Andaman Sea on 28 September. Moving northwestwards, it concentrated into a depression on the morning of 1 October with its centre at 0300 GMT near 15.5 deg. N, 91.0 deg. E. Then moving practically northwards, it lay over coastal Bangla Desh on the morning of 4th and weakened into a low over Tripura and neighbourhood the same noon.

In association with this system generally widespread rain with isolated heavy falls occurred in Andaman and Nicobar Islands on 1 October. Rainfall was also scattered to fairly widespread in coastal Orissa and Gangetic West Bengal on 2nd and 3rd and in Assam and adjacent states from 3rd to 5th, with a few heavy falls. The heavy rainfall amounts (cm) were: Nancowry 7 on 1st; Sandheads 9, Puri 7 on 2nd; Contai 9 on 3rd; Imphal 11 on 5th.

According to press reports over 3 lakhs people were marooned in the flash floods in *Imphal* and *Iril* rivers in Manipur. About 80 villages in Manipur central district and *Ekou* bridge on the *Imphal* river were completely washed away. Heavy loss to standing crops and property was also reported from this area.

This system was classified as a depression based mainly on satellite pictures and also the following reports from coastal observatories and ship. According to satellite bulletin from Bombay, this system was classified generally as T 2.0/2.0 from 1st to 3rd which gives the maximum wind in circulation as 30 kt. On 1st, Rangoon reported ESE/25 kt at 0000 GMT and ESE/25-35 kt at 0600 GMT at 0.6 and 0.9 km asl. The wind at Port Blair at these levels was WSW/40 kt at 1200 GMT on 1st and 30 to 35 kt at 0000 GMT on 2nd. Ship *ATIU* reported surface wind SW/15 kt at 1200 GMT on 2nd and N/15 kt at 0000 GMT on 3rd within 150 km from the depression centre. As the depression approached

the Bangla Desh coast on 4th, the pressure at Chittagong fell by about 5 mb at 0000 GMT since the last 24 hours. The pressure departure from normal at Chittagong at 0300 GMT on 4th near the centre of the depression was *minus* 6.5 mb. The recurvature of the depression towards Bangla Desh and Assam was mainly in association with a westerly trough in the middle and upper troposphere that was practically stationary from 3rd to 5th and extended from east Tibet to central India.

2.5. *Cyclonic storm of 16-19 October*

The first cyclonic storm of the year had its genesis in a low pressure area which moved westwards from Andaman Sea into southeast Bay and concentrated into a depression on the morning of 16 October. At this time it was centred near 10.0 deg. N, 88.0 deg. E. Moving westnorthwestwards initially and later northwestwards rather fast, it intensified into a cyclonic storm the next morning over west central Bay with its centre at 0300 GMT near 14.5 deg. N, 82.5 deg. E. Continuing to move northwest it lay close to coastal Andhra Pradesh as a deep depression on the morning of 18th with its centre about 50 km eastnortheast of Masulipatnam. It weakened further into a depression over land near Masulipatnam the same evening and into a low over the same area by 19th evening.

This system was classified as a depression on 16th based on the upper winds over Port Blair which were S/SSE 30-35 kt at 0.6 and 0.9 km asl. The satellite bulletin STDS from Washington that evening had classified this system as T 1.5/1.5 which is equivalent to a depression. The next day the STDS classified the system as T 2.0/2.0 (maximum wind in circulation 30 kt). The winds at 0.9 km asl at Madras was N/35 kt and at Visakhapatnam ENE/30 kt on 17th morning and N/45 kt at Gannavaram the same evening. The *ONGC* ship Frederiksburg located near 16.3 deg. N, 82.2 deg. E (off Masulipatnam) reported surface wind NE/30-45 kt from 0230 to 0930 GMT on 17th gusting to 50 kt at some hours. These observations suggested that the depression had intensified into a cyclonic storm on 17th. The strongest surface wind reported by a coastal observatory in Andhra Pradesh was ENE/30 kt at Kakinada on 17th. The surface wind reports from the *ONGC* ship on 17th night and 18th morning showed that the wind veered from NE to S and weakened gradually to 15 to 20 kt during that period. These observations and the fact that there was no damage due to wind suggest that the system was only a border case of a cyclonic storm and a deep depression on 17th while at sea and a deep depression while crossing coast on 18th morning. Masulipatnam reported the lowest pressure of 997.4 mb at 2300 GMT of 17th and the highest pressure departure of *minus* 10 mb at 0300 GMT of 18th. Assuming the maximum sustained wind associated with the storm as 40 kt, the lowest pressure at the storm centre works out to be 996 mb.

In association with this system generally widespread rain or thundershowers occurred in Andaman and Nicobar Islands on 16th, in coastal Tamil Nadu on 17th, in Telangana and Rayalaseema on 18th, in coastal Andhra Pradesh from 17th to 20th and in Orissa and Gangetic West Bengal on 18th and 19th. Very heavy rain occurred at many places in coastal Andhra Pradesh and south coastal Orissa on 18th. The notable amounts of heavy rainfall (cm) were:

Coastal Andhra Pradesh

Coringa 11, Bikkavolu 10 on 17th; Ichchapuram 34, Siddantham 30, Sompeta 27, Gummampadu 25, Atchanta (Koderu) 23, Kothapeta, Mamuduru 22 each, Kullalock 21 on 18th; Mehadrigadda 13 on 19th; Mehadrigadda 16, Mummadivaram 15, Sashugadda 14, Amalapuram 13, Adavipalam 12 on 20th.

Orissa

Berhampur 23, Gopalpur, Hiradharbati 19 each, Purushottampur 17, Madhavabanda, Madhabarid, Chatrapur 15 each, Palasora 13, Chandbali, Sarada 12 each, Puri, Mohana 11 each, Paradip, R. Udayagiri, Gosami 10 each on 18th.

Gangetic West Bengal

Sandheads 16, Sagar Island 7 on 18th; Purulia 12, Sandheads 8 on 19th.

No damage to life or property was reported due to wind associated with this system. But the heavy rain which occurred in east and west Godavari districts caused damage to standing paddy, banana and sugarcane crops and to roads, buildings and major irrigation work.

2.6. *Cyclonic storm of 3-7 December*

A low which was over southeast bay on 1 December moved westnorthwest and concentrated into a depression over southwest Bay on the morning of 3rd with its centre at 0300 GMT near 9.5 deg. N, 84.5 deg. E. The depression moved northwestwards, became deep on 4th morning and intensified into a cyclonic storm the same evening when it was centred near 12.0 deg. N, 82.5 deg. E. The storm started recurving northeastwards on 5th. It weakened into a deep depression on 5th evening and into a low over west central Bay by the morning of 8th.

Reports from many ships were available on the periphery of this disturbance. Some of the important reports from the ships and coastal observatories are given in Table 4. This system was classified as T 2.0/2.0 on 4th morning and as T 3.0/3.0 on 4th evening and 5th morning in STDS. The system was downgraded to T 1.0/2.0 by 6th morning. A satellite view of this disturbance on the morning of 6th is shown in Fig. 3.The maximum sustained wind associated with this storm on the basis of ship's reports and satellite pictures was about 40 kt. For this maximum wind, the pressure estimated at the centre of the storm was 998 mb. The track of this disturbance was roughly along the western periphery of the upper tropospheric anticyclone which was located over south Burma and adjoining Andaman Sea. The storm dissipated over the sea itself as it moved into apparently cooler waters.

Under the influence of this system, generally widespread rain or thundershowers occurred in Andaman and Nicobar Islands from 1st to 3rd and scattered to fairly widespread rain occurred over north Tamil Nadu, coastal Andhra Pradesh and Rayalaseema between 4th and 6th with isolated heavy to very heavy falls in Tamil Nadu on 5th. Madras airport and Mayuram in Tamil Nadu reported 13 cm and 9 cm of rain respectively on 5th. No damage to life or property was caused by this system.

2.7. *Cyclonic storm of 12-17 December*

A low pressure area which was over south Andaman Sea on 10th, moved westwards across Nicobar Islands on 11th and concentrated into a depression on the morning of 12th with its centre at 0300 GMT near 10.5 deg. N, 91.5 deg. E. It meandered through Andaman and Nicobar Islands between 12th evening and 14th evening as a deep depression and emerged into southeast Bay on the morning of 15th. Then moving westwards, it intensified into a cyclonic storm on the morning of 16th with its centre at 0300 GMT near 8.5 deg. N, 87.0 deg. E. Continuing to move westwards, it crossed Sri Lanka coast on the forenoon of 17th near Trincomalee and weakened into a depression over Sri Lanka. The depression emerged into Gulf of Mannar that evening and weakened further into a low over Comorin by 18th morning.

Three closed isobars at 2 mb interval covered the depression field from 12th to 15th. The pressure departure from normal near the centre of the depressions was about *minus* 7 mb during the above period. Port Blair reported E/30-35 kt wind at 0.9 km asl on 14th. The same day Hut Bay reported surface wind NE/30 kt both at 0300 and 1200 GMT and ship *ATRC* near Hut Bay also reported surface wind NE/32 kt at

TABLE 4

Cyclonic storm of 3-7 December 1980

Date	Time (GMT)	Ship (locations °N, °E) station	Appr. distance from storm centre (km)	Wind Dir.	Wind Speed (kt)	Pressure (mb)
3	00	ATHR (10.5, 83.6)	175	NNE	19	1006.0
	00	VWNW (10.3, 82.4)	250	N	33	1006.8
	12	ATGN (11.8, 84.7)	200	NE	25	1005.3
4	00	Karaikal		N (upto 0.9 km asl)	25	
	06	VWCK (9.9, 80.7)	250	NW	24	1008.5
	06	GVAM (11.2, 84.6)	200	S	21	1006.4
	09	GVAL (13.1, 80.4)	250	NNW	24	—
	12	VWCK (10.6, 80.3)	275	NW	25	1007.3
	12	GVAM (10.0, 84.0)	250	SSW	24	1004.7
	12	Madras		N (upto 0.9 km asl)	30-40	—
5	00	Madras		NNW	20	1007.4
	06	ATJX (10.7, 84.0)	300	W	25	1008.2
	06	PCPG (11.0, 84.9)	300	SW	23	1007.5
	06	Madras		NNW-N (at 0.6 & 0.9 km asl)	40-45	
	12	PCPG (11.5, 83.3)	225	WSW	20	1004.6
	12	Madras		N (at 0.9 km asl)	35	
6	00	ATJX (13.5, 84.7)	100	SSE	22	1004.7
	00	PCPG (12.4, 81.5)	300	270	24	1007.0
	06	ATJX (14.6, 84.6)	75	E	17	1006.7
	12	ATJX (16.0, 84.1)	150	N	30	1004.6
	12	ATKE (17.0, 84.1)	250	NE	30	1006.0

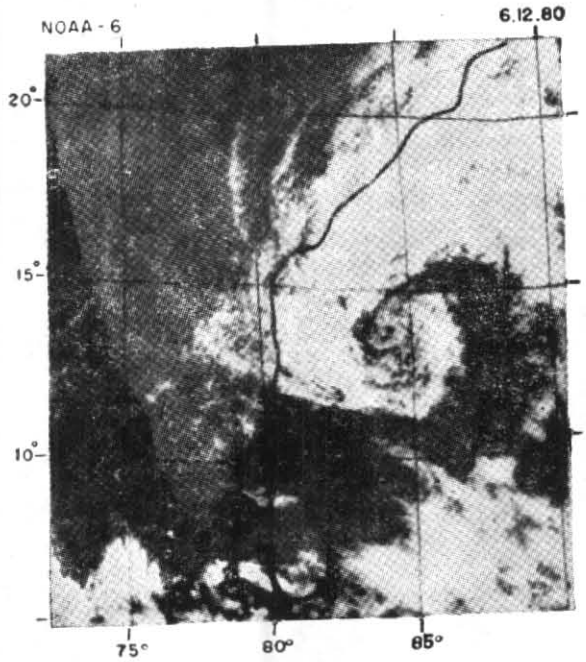

Fig. 3. Satellite view of the Bay storm after weakening into a depression at 0234 GMT on 6 Dec 1980

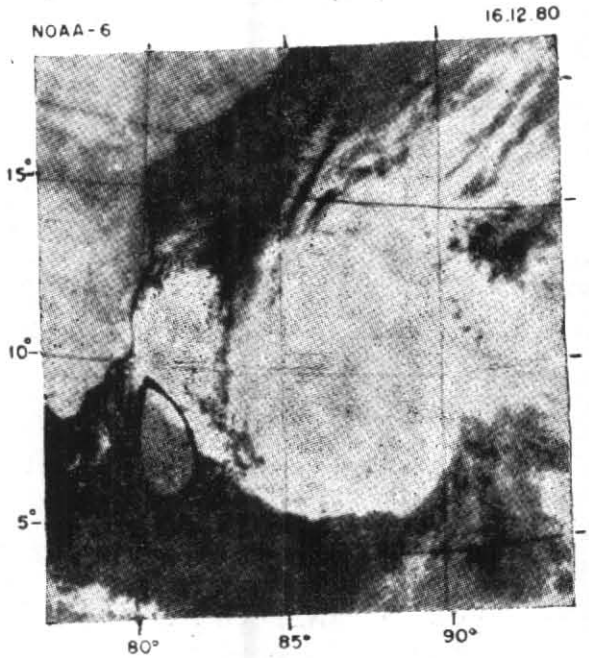

Fig. 4. Bay cyclone as seen by satellite at 0212 GMT on 16 December 1980

1200 GMT and E/25 kt at 1500 GMT. These showed that the system was a deep depression during the above period. The system was upgraded into a cyclonic storm on 16th based on satellite picture as well as reports from ship *VWWT*. The disturbance was classified as T 2.5/2.5 in STDS on this day and as T 3.5/3.5 in the satellite bulletins issued by Bombay and Delhi. The maximum sustained wind as per these classifications was 35 to 55 kt. A satellite view of this storm on the morning of 16th is reproduced in Fig. 4. Ship *VWWT* reported surface wind NNW/25 kt at 0600 GMT on 16th near 8.5 deg. N, 83.5 deg. E, NE/E 30 kt at 1200 and 1500 GMT near 9.3 deg. N, 83.7 deg. E and ESE/30 kt at 1800 and 2100 GMT near 9.5 deg. N, 84.0 deg. E. It reported the lowest pressure of 1,005.9 mb at 1200 GMT about 200 km to the northwest of the storm centre. Ship *ATJJ* near 11 deg. N, 84.5 deg. E reported surface wind ENE/25 kt at 0900 GMT on 16th. As the storm approached Sri Lanka coast on 17th, Trincomalee reported surface wind N/30 kt at 0000 GMT and the lowest pressure of 1001 mb at 0300 GMT when the storm centre came close to that station. The pressure departure from normal at that time over that station was *minus* 11 mb. The same morning at 0600 GMT Karaikal about 300 km to the northnorthwest of the storm centre reported northeasterly wind of 40 to 45 kt upto 0.9 km asl. Assuming the maximum wind associated with the storm as 40 kt, the pressue at the centre of the storm works out to be about 998 mb.

The eastward movement of the depression from 12th to 13th appears to be under the influence of a trough in the middle and upper tropospheric westerlies which lay extending from west Tibet to north Peninsula on 12th and moved eastwards across Burma by 14th.

In association with this system, generally widespread rain occurred over Andaman and Nicobar Islands from 11th to 16th with a few heavy to very heavy falls from 12th to 14th. Port Blair recorded exceptionally heavy rainfall of 20 cm and 22 cm on 12th and 13th respectively. Hut Bay recorded 17 cm on 12th. Generally widespread rain with isolated heavy falls occurred over south Tamil Nadu on 18th and 19th. The heavy rainfall amounts (cm) were: Kanniyakumari 9, Nagapattinam, Mannargudi 7 each on 18th; Tuticorin 9 on 19th.

3. Arabian Sea

3.1. *Depression of 4-6 June*

In the trough which lay over Lakshadweep and adjoining east central Arabian Sea off Karnataka, Goa coasts, a low developed off Karnataka coast on 3 June moved slowly northwards and concentrated into a depression over east central Arabian Sea off Karnataka, Goa, south Maharashtra coasts on the morning of 4th with its centre near 15 deg. N, 70.5 deg E. The depression moved northnortheastwards, crossed north Maharashtra coast by 6th afternoon and weakened into a low over northern parts of interior Maharashtra the same evening.

Under the influence of this system the southwest monsoon advanced into entire Karnataka and Maharashtra states between 4th and 6th. Generally widespread rain occurred over these areas and adjoining Gujarat between 4th and 7th with a few heavy to very heavy falls. Ahwa in Dangs district of Gujarat recorded a very heavy fall of 25 cm on 7th. The other significant amounts of rainfall (cm) were : Coondapur 7 on 4th ; Karwar, Mangalore 9 each on 5th ; Dahanu 15, Honavar 11, Bagamandala (Karnataka) 10, Kalyan, Shirali 9 each on 6th; Dahanu 10, Bombay 9 on 7th.

This system was classified as a depression on the basis of the low level winds and pressure departures from normal along the west coast. On 4th Goa reported SE/S 25 kt upto 0.9 km asl at 0000 GMT, and reported surface wind SE/20 kt at 0000 GMT of 5th and the pressure departure from normal that morning at Goa and Devgarh was *minus* 5 mb. That evening the low level winds (upto 0.9 km asl) at Ratnagiri strengthened to S/SW 30 kt. At 0000 GMT on 6th, Bombay reported E/25 kt upto 0.9 km asl and the pressure departure from normal at Bombay at 0300 GMT was *minus* 8 mb.

The recurvature of the depression northeastwards appears to be under the influence of a trough in the middle and upper tropospheric westerlies which moved across northwest India and Gujarat between 5th and 7th.

3.2. *Deep depression of 14-19 October*

A depression formed in west central Arabian Sea on the morning of 14 October with its centre at 0300 GMT near 12.5 deg. N, 61.0 deg. E. Moving practically westwards, it dissipated over the Gulf of Aden by 19th evening.

This system did not affect the weather over India. It was classified as T 1.5/1.5 on 16th, T 2.0/2.0 on 17th, T 2.5/2.5 on 18th and as T 1.5/1.5 on 19th morning in the STDS received from Washington. The intensity and centre of this disturbance was estimated mainly on the basis of the satellite bulletin from Washington and Bombay. This system was probably a deep

depression on 17th and 18th as per satellite classification and reports from one or two ships. On 17th morning (0300 and 0600 GMT) ship *VWXQ* near 14 deg. N, 53 deg. E reported surface wind NNE/30 kt. The same evening it reported surface wind 070/20 kt near 14.5 deg. N, 54.0 deg. E and relatively low MSL pressure of 1005.3 mb while ship *UXYH* near 12 deg. N, 58.5 deg. E reported surface wind SE/15 kt and MSL pressure of 1012.5 mb. These showed that the depression was probably deep on 17th.

3.3. *Deep depression of 13-20 November*

A low pressure area entered into Arabian Sea across south Peninsula on 12th November. It concentrated into a depression by the evening of 13th with its centre at 1200 GMT near 12 deg. N, 71 deg. E. Moving northwestwards intially and westwards later, it weakened into a low over west central Arabian Sea by the morning of 21st. The depression was deep from 17th to 20th morning.

In association with this system and another low pressure area which lay over south west Bay off Sri Lanka, south Tamil Nadu coasts from 14th to 16th, there was good incursion of moisture into south Peninsula and Maharashtra and Gujarat States leading to generally widespread rain in south Peninsula and Lakshadweep from 13th to 16th and generally scattered rainfall in Konkan and Goa and Madhya Maharashtra from 15th to 19th. Isolated rainfall also occurred in Gujarat State on 16th and 17th.

This system was classified as a depression on 13th evening based on the pressure and wind observations of Amini and reports from two ships about 350 km to the northwest and northeast of the centre of the disturbance. On 17th morning three closed circular isobars covered the depression field and the satellite picture also suggested that the depression had become deep. On the morning of 18th ship *PJOM* reported ENE/27 kt about 350 km to the north of the depression centre. Ship *ATKJ* passed close to the depression centre (within 100 km) on 20th morning. It reported a wind shift from NE/22 kt at 0300 GMT to ESE 25 kt at 0400 GMT on 20th near 17 deg. N, 63 deg. E. The lowest MSL pressure reported by this ship was 1002.8 mb at 0300 GMT on 20th. On this basis the estimated pressure departure from normal near the depression centre was about *minus* 13 mb.

The satellite bulletin received from the Joint Typhoon Warning Centre (JTWC) Guam had classified this system as T 1.5/1.5 on 13th and 14th, T 2.0/2.0 on 15th and 16th and as T 2.5/2.5 on 17th and 18th. In the STDS from Washington this system was classified as T 1.5/1.5 on 16th, T 3.0/3.0 on 17th and T 2.5/3.0 on 18th morning and T 1.5/2.5 that evening. According to these classifications this system was a cyclonic storm on 17th and 18th with maximum winds of 35 to 45 kt in circulation. In the *"Annual Tropical Cyclone Report 1980"* published by JTWC, Guam, the disturbance is mentioned to have become a storm on 17th and 18th and recurved northeast after 17th towards Indian coast and dissipated by 20th, while a secondary circulation developed on 17th and moved westwards to Arabia cost. The observations from the coastal observatories in India and ships' reports in the Arabian Sea did not indicate any disturbance recurving northeastwards to the Indian coast. The main disturbance moved only westwards after 17th as shown in Fig. 1.

4. Land depressions

4.1. *Depression of 20-25 June*

A low pressure area which was over Bihar Plateau and adjoining Gangetic West Bengal on 18 June became well marked on 19th and moving westwards, concentrated into a depression on the evening of 20th over east Madhya Pradesh with its centre at 1200 GMT near Mandla. Then moving northwestwards initially across north Madhya Pradesh and later westwards rather fast across south Rajasthan, it emerged into north Arabian Sea on 24th and weakened into a low by 25th evening.

Under the influence of this system, the monsoon advanced into Bihar State on 19th, Madhya Pradesh and Uttar Pradesh on 21st and Gujarat State and east Rajasthan on 23rd. Rainfall was generally widespread in Gangetic West Bengal, Orissa, Bihar State and east Madhya Pradesh from 19th to 21st, in Uttar Pradesh on 21st and 22nd, in west Madhya Pradesh from 21st to 23rd, in Gujarat State from 22nd to 25th and in east Rajasthan on 23rd. Heavy to very heavy rain occurred in Orissa, Madhya Pradesh and Gujarat State on a few days and in east Rajasthan on 23rd. The significant amounts of heavy rainfall (cm) were : Jharsuguda 12, Rajnandgaon (Madhya Pradesh) 11 on 19th; Jharsuguda 11 on 20th ; Raigarh 13, Maihar (Madhya Pradesh) 11, Panna, Sidhi 10 each on 21st; Bhonpura (Madhya Pradesh) 12, Nowgong 11 on 22nd ; Neemuch 26, Manasa (M.P.) 15, Jawad (M.P.) 14, New Kandla 13, Sirohi 12, Dungarpur, Surat, Daman 11 each, Idar 10 on 23rd ; Porbandar 10 on 24th.

This system was classified as a depression mainly on the strength of the low level winds in circulation. On most of the days only one closed circular isobar could be drawn. On 20th evening, Jabalpur reported NNE/30 kt and Nagpur NNW/25 kt at 0.9 km asl and the pressure departure from normal near the centre at that time was *minus* 4 mb. These formed the basis for classifying the well marked low as a depression over east Madhya Pradesh on 20th evening. The next morning, the easterlies at 0.9 km asl over east Uttar Pradesh strengthened to 30 to 40 kt. To the south of the system, Jabalpur reported W/30 kt at 0.9 km asl. Two closed isobars covered the depresion field at 0300 GMT on 21st. The depression apparently weakened into a low on 22nd as the low level winds in circulation were only 15 to 20 kt. However, on 23rd morning the system reintensified into a depression. The pressure departure from normal near the centre was *minus* 6 mb and the low level wind at Jodhpur was ENE/35 - 40 kt on this day. In association with this system, the easterlies were generally stronger than the westerlies.

4.2. *Depression of 10 - 11 August*

A low pressure area which was over central parts of Uttar Pradesh on 9th concentrated into a depression on the morning of 10th with its centre at 0300 GMT about 50 km southwest of Kanpur. It moved a little southeastwards by the next day and weakened into a low *insitu* by 12th.

This system caused generally widespread rain in Uttar Pradesh and adjoining Madhya Pradesh from 10th to 12th with a few heavy to very heavy falls. The significant amounts of heavy rainfall (cm) were : Laundi (M.P.) 22 on 10 ; Laundi (M.P.) 28, Banda 22, Hamirpur 12 on 11th, Jhansi 19, Karwi (Uttar Pradesh) 15, Nowgong 14 on 12th.

The pressure departure from normal near the centre of the depresion was *minus* 6 mb. Two closed isobars at 2 mb interval covered the depression field. Lucknow reported SE/30 kt between 0.3 and 0.9 km asl at 0000 GMT on 10th and E/20-25 kt at 0000 GMT on 11th at these levels.

4.3. *Depression of 25 - 30 August*

A low which was over east Uttar Pradesh on 24th concentrated into a depression on the evening of 25th over southeast Uttar Pradesh with its centre between Allahabad and Varanasi. The depression was practically stationary in that area till 26th evening and weakened into a low *insitu* that night. The low persisted there on 27th. Under the influence of another low (remnants of depression from northeast Bay) which was over Bihar on 27th morning and moved westwards that evening, the low reintensified into a depression by 28th morning over southeast Uttar Pradesh and adjoining northeast Madhya Pradesh with its centre at 0300 GMT near Sidhi. Moving westwards across north Madhya Pradesh, the depression weakened into a low over northwest Madhya Pradesh and adjoining southeast Rajasthan by 30th noon.

In association with this system generally widespread rain occurred in the plains of Uttar Pradesh from 25th to 29th, in Bihar plains from 25th to 27th, in Madhya Pradesh from 27th to 29th, in west Madhya Pradesh and adjoining east Rajasthan on 30th and in Gujarat region on 30th and 31st, with some heavy to very heavy falls in Uttar Pradesh, Madhya Pradesh and Bihar plains. The significant amounts of heavy rainfall (cm) were : Allahabad 21, Deoria 12, Elgin bridge (Uttar Pradesh), Motihari 10 each on 25th; Meja (Uttar Pradesh) 25, Allahabad, Dataganj 22 each, Laundi (M.P.) 19, Rae Bareli 16, Panna 13, Chhatarpur 11, Patna 10 on 26th; Orai 20, Bijawar (M.P.) 19, Panna 16, Laundi (M.P.) 15, Chillaghat (Uttar Pradesh), Jhansi 13 each, Datia 11 on 27th; Khajuraho 32, Buxwaha (M.P.) 21, Bijawar (M.P.) 18, Nowgong 14, Panna 13, Jabalpur 10 on 28th; Jabera (M.P.) 29, Jabalpur 23, Pachmari 21, Deori (M.P.), Narsinghpur 20 each, Chhatarpur 14 on 29th; Alot (M.P.), Khategaon (M.P.) 17 each, Hoshangabad, Ujjain 12 each, Shajapur 11 on 30th. On account of the heavy rain, floods affected Madhya Pradesh and Uttar Pradesh disrupting road and rail communications.

Allahabad reported surface wind W/20 kt and Varanasi WSW/15 kt at 1200 GMT of 25th. The pressure departure near the centre of the depression at this time was about *minus* 5 mb. Lucknow and Gorakhpur reported NE/E 30-35 kt winds at 0.6 and 0.9 km asl at 0000 GMT on 26th and the pressure departure near the depression centre on 26th morning was about *minus* 6 mb. On 28th and 29th morning three closed isobars at 2 mb interval covered the depression field and the pressure departure from normal near the centre of the depression on these days was about *minus* 5 mb.

4.4. *Depression of 5 - 6 September*

A low which was over northwest Bay on 3 September moved northwestwards to southeast Uttar Pradesh by 5th morning and concentrated into a depression at 0300 GMT with its

centre about 50 km northeast of Allahabad. Then moving westnorthwest, it weakened into a low by the morning of 7th over southwest Uttar Pradesh.

The depression caused generally widespread rain with heavy to very heavy falls in Uttar Pradesh on 6th and 7th. The rainfall occurred mainly to the north and east of the depression centre. The principal amounts of heavy rainfall (cm) were : Lucknow (IAF) 15, Bhatpurwaghat 14, Kanpur (IAF) 13, Bansgaon, Birdghat 12 each, Varanasi 11, Akbarpur, Bansi 10 each on 6th; Gonda 12, Etah, Ayodhya, Azamgarh 10 each on 7th.

The pressure departure from normal near the centre of the depression on 5th was about *minus* 5 to 6 mb. Generally two closed isobars at 2 mb interval covered the depression field. Lucknow reported ENE/30 kt at 1200 GMT on 5th and SE/25-30 kt at 0000 and 1200 GMT on 6th at 0.6 and 0.9 km asl. Agra reported NNW/30 kt at these levels at 1200 GMT of 6th. The surface wind at Kanpur was NNW/20 kt at 0000 GMT and SE/20 kt at 0600 GMT on 6th.