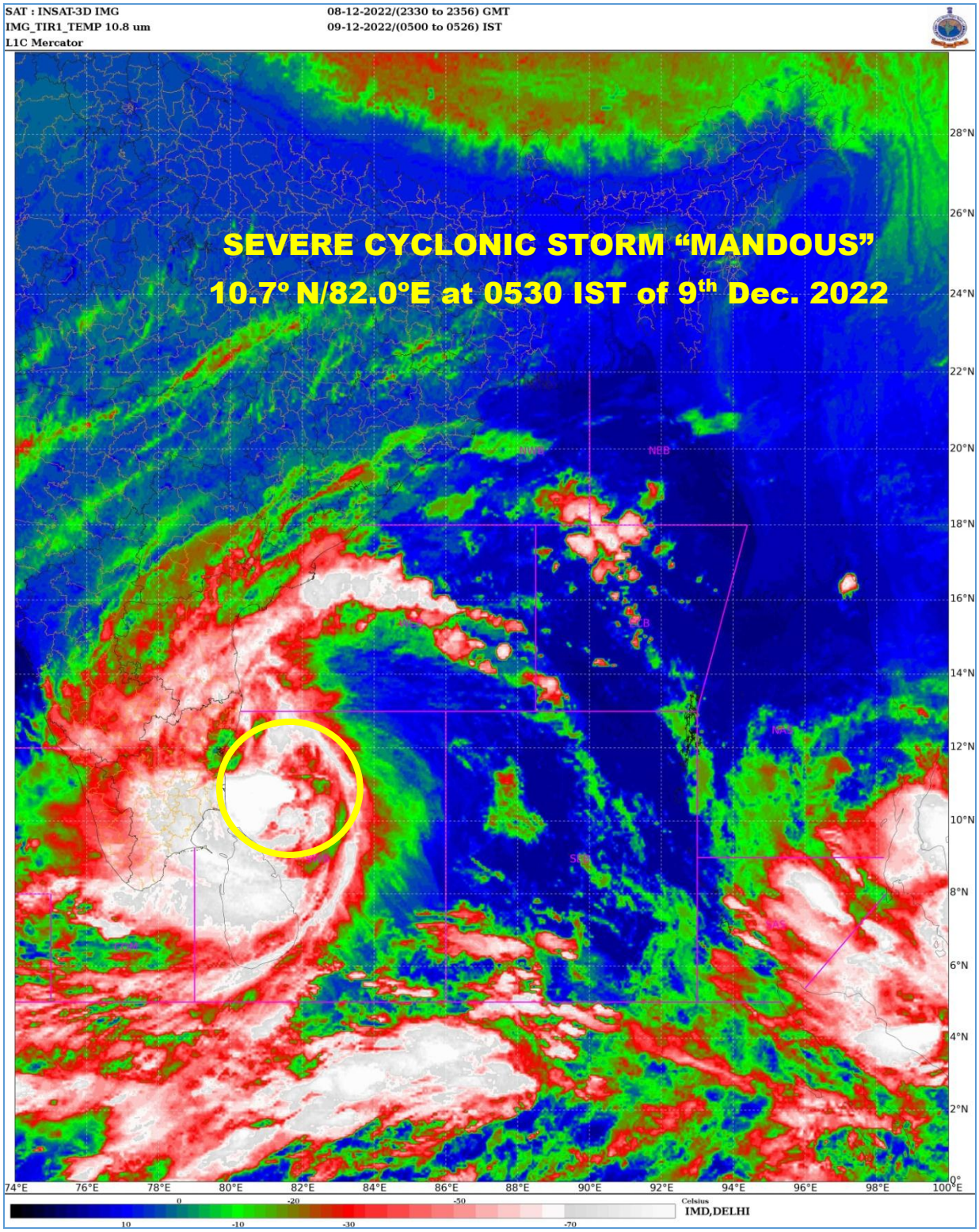
Severe Cyclonic Storm “MANDOUS” over the BoB (6th-10th December, 2022): A Report



Cyclone Warning Division
India Meteorological Department
New Delhi

Severe Cyclonic Storm "MANDOUS" over the BoB (6^{th}-10^{th} December, 2022): A Report

1. Life History of MANDOUS:

- A remnant upper air cyclonic circulation from south China Sea lay over south Andaman Sea and adjoining equatorial Indian Ocean and strait of Malacca in the morning (0530 hours IST) of 4th December. Under its influence, a low pressure area (LPA) formed over South Andaman Sea & neighbourhood in the morning (0530 hours IST) of 5th December, 2022. It became a well marked low pressure area (WML) over Southeast Bay of Bengal (BoB) in the morning (0530 hours IST) of 06^{th} December 2022.
- Under favourable environmental conditions, the WML concentrated into a depression over Southeast BoB in the evening (1730 hours IST) of 6^{th} December.
- It moved west-northwestwards and intensified further into a deep depression (DD) over southeast & adjoining southwest BoB in the morning (0530 hours IST) of 7^{th} December.
- Continuing to move west-northwestwards, it further intensified into the cyclonic storm (CS) "Mandous" pronounced as "Man-Dous" over southwest BoB around midnight (2330 hours IST) of 7^{th} December and into a severe cyclonic storm (SCS) in the evening (1730 hours IST) of 8^{th} December.
- It maintained the intensity of SCS till early hours of 9^{th} December. The peak intensity of the storm was 85-95 kmph gusting to 95 kmph during this period
- Thereafter, continuing to move west-northwestwards, it entered unfavourable environment (moderate to high wind shear, interaction with land surface, relatively colder sea and lower Ocean heat content (less than 50 KJoules/second)) and weakened into a CS over southwest BoB off north Tamilnadu and Puducherry coasts in the morning (0530 hours IST) of 9^{th} December.
- It then moved nearly northwestwards, weakened gradually and crossed north Tamil Nadu, Puducherry and adjoining south Andhra Pradesh coasts between Puducherry and Sriharikota, near latitude 12.60°N and longitude 80.15°E, close to Mamallapuram (Mahabalipuram) during midnight (2330 hours IST) of 9^{th} and early hours (0230 hours IST) of 10^{th} December as a CS with the maximum sustained wind speed (MSW) of 65-75 kmph gusting to 85 kmph.
- After the landfall, it moved west-northwestwards and weakened into a DD over North Tamil Nadu in the early morning (0530 hours IST) of 10th December. It then moved west-southwestwards and weakened into a depression over North Tamil Nadu around noon (1130 hours IST), into a WML over north interior Tamil Nadu in the evening (1730 hours IST) of 10^{th} December and into an LPA over north interior Tamil Nadu and adjoining South Interior Karnataka & north Kerala in the morning (0530 hours IST) of 11^{th} December.
- The observed track of the system (depression to depression) is presented in **Fig. 1**. The best track parameters of the system are presented in **Table 1**.

2. Salient Features

(i) Climatologically, about 25 cyclones (MSW ≥ 62 kmph) developed over the BoB **(Fig. 2a)** in the month of December with 15 severe cyclones (MSW ≥ 89 kmph). Out of the total 25 cyclones over the BoB, 9 crossed Tamil Nadu coast with 1 as depression (MSW: 31-49 kmph), 1as CS (MSW ≥ 62-88 kmph)(**Fig. 2b**) and 7 crossed Tamil Nadu coast as a severe cyclonic storm (MSW ≥ 89 kmph) (**Fig. 2c**).

(ii) **Recurving track:** Mandous had a recurving track. Initially, it moved west-northwestwards till evening (1730 hours IST) of 7th December and then northwestwards till landfall. After landfall, it moved west-northwestwards till morning (0530 hours IST) of 10th and then west-southwestwards. This kind of movement was mainly due to the fact that the system was steered over the sea by the anticyclone to the northeast of system centre in the middle and upper tropospheric levels. As the system approached the coast, it lay in the southwest periphery of the anticyclone leading to the change in direction of movement from west-northwestwards to northwestwards. However, as it reached near to the coast and weakened, the steering force changed with decrease in vertical extension of the system. Thereafter, the system got steered by east-northeasterly winds in lower and middle tropospheric levels leading to gradual west-southwestwards recurvature after the landfall (**Fig.1**).

(iii) **Translational Speed:** Mandous exhibited six hourly average translational speed of 12.0 kmph against normal of 15.5 kmph for severe cyclonic storms over the BoB in the post monsoon season during 1990-2013 (**Fig.3a**).

(iv) **Life period:** The life period of the storm (depression to depression) was about 96 hours (4 days) against the long period average (LPA) (1990-2013) of about 96 hours (4 days) for SCS category over the BoB during post-monsoon season.

(v) Maximum sustained wind speed and estimated central pressure: The system did not exhibit any rapid intensification/weakening during it's life cycle. The system reached it's peak intensity of 50 knots at 1200 UTC of 8th December and maintained it till 0000 UTC of 9th December. The estimated central pressure during this period was 990 hPa. The six hourly maximum sustained wind speed and estimated central pressure during the life cycle of Mandous are presented in **Fig. 3b.**

(vi) **Damage Potential and Power Dissipation Index**: The Accumulated Cyclone Energy (a measure of damage potential) and Power Dissipation Index (a measure of loss) in association with Mandous were 1.72 X 10^4 knots^2 and 0.77 X10^6 knots^3 respectively against the normal of 1.83 X 10^4 knots^2 and 0.90 X10^6 knots^3 for SCS during post monsoon season over the BoB based on the data during 1990-2020.

Table 1: Best track positions and other parameters of the severe cyclonic storm Mandous over the Bay of Bengal during 6th-10th December, 2022

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E		C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
06.12.22	1200	8.2	88.2	1.5	1000	25	3	D
	1800	8.4	87	1.5	1000	25	4	D
07.12.22	0000	8.6	86.3	2.0	999	30	5	DD
	0300	8.7	85.7	2.0	999	30	5	DD
	0600	8.7	85.5	2.0	998	30	5	DD
	1200	8.9	85.0	2.0	998	30	6	DD
	1800	9.2	84.6	2.5	997	35	7	CS

	2100	9.3	84.4	2.5	997	35	7	CS
08.12.22	0000	9.4	84.1	2.5	995	40	8	CS
	0300	9.5	83.8	2.5	994	40	9	CS
	0600	9.7	83.5	2.5	992	45	10	CS
	0900	9.8	83.2	2.5	992	45	10	CS
	1200	10.1	82.9	3.0	990	50	12	SCS
	1500	10.4	82.6	3.0	990	50	12	SCS
	1800	10.6	82.3	3.0	990	50	12	SCS
	2100	10.7	82.0	3.0	990	50	12	SCS
09.12.22	0000	11.0	81.7	3.0	990	50	12	SCS
	0300	11.1	81.5	2.5	991	45	11	CS
	0600	11.4	81.3	2.5	992	45	10	CS
	0900	11.7	81	2.5	992	45	10	CS
	1200	12.0	80.8	2.5	993	40	9	CS
	1500	12.2	80.6	2.5	994	40	8	CS
	1800	12.5	80.3	2.5	995	35	7	CS
	Crossed North Tamil Nadu & Puducherry and adjoining south Andhra Pradesh coasts between Puducherry and Sriharikota near latitude 12.6°N and longitude 80.15°E, close to Mamallapuram (Mahabalipuram) during 1800-2000 UTC of 09th December as a Cyclonic Storm with the maximum sustained wind speed of 35 knots (65-75 kmph gusting to 85 kmph)							
	2100	12.8	80	-	996	35	7	CS
10.12.22	0000	12.9	79.7	-	998	30	5	DD
	0300	12.8	79.5	-	1000	30	4	DD
	0600	12.7	79.3	-	1002	25	3	D
	1200	Weakened into a well marked low pressure area over north interior Tamil Nadu and neighbourhood						

3. Monitoring of Cyclonic Storm, MANDOUS:

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the cyclone was monitored since 24th November, about 10 days prior to the formation of cyclonic circulation over South Andaman Sea & adjoining equatorial Indian Ocean on 4th December, 11 days prior to formation of LPA over South Andaman Sea on 5th December and 12 days prior to actual genesis (formation of depression) on 6th December. The information about the system was first released in the weekly extended range outlook issued by IMD on 24th November, indicating formation of depression over southeast BoB around 6th-7th December with low probability (1-25%) about 12 days in advance. Further, the extended range outlook issued on 1st December, indicated formation of depression around 6th-7th December with high probability (68-100%) about 5 days in advance.

The cyclone was monitored with the help of available satellite observations from INSAT 3D and 3DR, polar orbiting satellites, available ships & buoy observations in the region, Doppler Weather Radar (DWR) Karaikal & Chennai and observations from coastal observatories of Tamil Nadu and Andhra Pradesh. On the day of landfall observations from DWR Chennai and Karaikal were utilised for monitoring the system. Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM and INCOIS were utilized to predict the genesis, track, landfall and intensity of the cyclone as well as associated severe weather. A digitized forecasting system of IMD was utilized for analysis and comparison of

various observations and numerical weather prediction models guidance, decision making process and warning products generation. Typical satellite based imageries from INSAT 3D (R) and sea surface wind based on Advanced Scatterometer (ASCAT), typical radar imagery from DWR Chennai are presented in **Fig.4**. The forecasts were mainly based on multi-model ensemble techniques developed by IMD.

4. Realised adverse weather

(a) Heavy rainfall

Light to moderate rainfall at most places with

- isolated heavy to very heavy rainfall occurred over Andaman and Nicobar Islands on 5th and 6th December,
- isolated heavy to very heavy rainfall occurred over north Tamil Nadu, Rayalaseema and south coastal Andhra Pradesh on 8th
- isolated heavy to very heavy rainfall at a few places and isolated extremely heavy rainfall occurred over north Tamil Nadu, Puducherry, Rayalaseema and south coastal Andhra Pradesh on 9th
- isolated heavy to very heavy rainfall over south coastal Andhra Pradesh and isolated heavy rainfall over north Tamil Nadu, Rayalaseema, south Interior Karnataka and Kerala on 10th.

The realised rainfall during past 24 hours at various stations of Andaman & Nicobar Islands, Tamil Nadu, Puducherry, coastal Andhra Pradesh, Rayalseema, South Interior Karnataka and Kerala from various stations is presented in **Fig. 5.** IMD NCMRWF satellite gauge merged plots indicating realised rainfall during past 24 hours ending at 0300 UTC of date are presented in **Fig. 6.**

Past 24 hours realised heavy rainfall (7 cm and above) recorded at 0830 hrs IST of date are given below.

6th December: Long Island-14.

7th December: Long Island-8.

8th December: Nil

09th December: Tamil Nadu: Chennai: Nungambakkam, Meenambakkam, CD Hospital Tondiarpet, AWS Chennai, Madhavaram_AMFU, YMCA Nandanam ARG-7 each;

10th December

Tamil Nadu and Puducherry: Vembakkam (dist Tiruvannamalai) 25, Minnal (dist Ranipet), Panapakkam (dist Ranipet) 20 each, Kancheepuram (dist Kancheepuram) 19, Cheyyar (dist Tiruvannamalai) 18, Avadi (dist Tiruvallur) 17, Tiruttani (dist Tiruvallur), KVK Kattukuppam Agro (dist Kancheepuram) 16 each, Ayanavaram Taluk Office (dist Chennai), Kundrathur (dist Kancheepuram) 15 each, Arakonam (dist Ranipet), Uthiramerur (dist Kancheepuram) , Perambur (dist Chennai) 14 each, Gummidipoondi (dist Tiruvallur), Tambaram (dist Chengalpattu), Sriperumbudur (dist Kancheepuram), Mahabalipuram (dist Chengalpattu), Cholavaram (dist Tiruvallur), Pallipattu (dist Tiruvallur), MGR Nagar (dist Chennai), Alandur (dist Chennai), Uthukottai (dist Tiruvallur) 13 each, Ambathur (dist Tiruvallur), Red Hills (dist Tiruvallur), Chengalpattu (dist Chengalpattu), Koratur (dist Tiruvallur), Chennai Ap (dist Chennai) 12 each;

Rayalaseema: Srikalahasti (dist Chittoor) 23, Thottambedu (dist Chittoor) 22, Kodur (dist Ysr District) 20, Nagari (dist Chittoor) 18, Satyavedu (dist Chittoor) 13, Tirupati Aero (dist Chittoor) 13, Palasamudram (dist Chittoor) 8, Rajampet (dist Ysr District) 8, Pullampeta (dist Ysr District) 7;

Coastal Andhra Pradesh: Gudur (dist Spsr Nellore) 20, Venkatagiri (dist Spsr Nellore) 17, Sullurpeta (dist Spsr Nellore) 16, Nellore (dist Spsr Nellore) 13, Tada (dist Spsr Nellore) 12, Rapur (dist Spsr Nellore) 12, Atmakur (dist Spsr Nellore), Kavali (dist Spsr Nellore) 7 each.

11th December:

Coastal Andhra Pradesh: Atmakur (dist SPSR Nellore) 13, Markapur (dist Prakasam), Amalapuram (dist East Godavari) 10 each, Veligandla (dist Prakasam), Kandukur (dist Prakasam) 9 each, Marripudi (dist Prakasam), Ongole (dist Prakasam), Udayagiri (dist Spsr Nellore) 8 each, Podili (dist Prakasam), Avanigada (dist Krishna), Konakanamitla (dist Prakasam) 7 each.

Rayalaseema: Thambalapalle (dist Chittoor), Venkatagiri Kota (dist Chittoor), Penagaluru (dist Ysr District), Arogyavaram (dist Chittoor) 7 each.

Tamil Nadu: Yercaud (dist Salem) 10, Vadapudupattu (dist Tirupattur) 9, Ambur (dist Tirupattur) 8, Wallajah (dist Ranipet), Arcot (dist Ranipet), Ammoor (dist Ranipet) 7 each;

South Interior Karnataka: Chintamani (dist Chikaballapura) 7

Kerala: Palluruthy ARG (Ernakulam district) 11, Mancompu (Alappuzha district) 9, NAS Kochi (Ernakulam district) 8, Piravam (Ernakulam district), Ernakulam South & Vynthala (Thrissur district) 7 each;

(b) Wind:

The maximum sustained wind speed during the landfall is estimated as 65-75 kmph gusting to 85 kmph. The wind speed observations recorded in different stations of coastal Tamil Nadu, Puducherry **(Table 2 a & b)** and Andhra Pradesh **(Table 3)** are presented below:

Table 2a: Recorded wind speed during 09.12.2022 evening to 10.12.2022 morning

Station	Date & Time (IST)	Wind Speed(Kmph)
Chennai (Numbamkam)	09/21:30:	41
Chennai (Meenambkam)	09/23:30-10/00:30	46
Puducherry	10/01:30	52

Table 2b: Maximum wind in gustiness reported by AWS

Station	Aws/Agro AWS	Gust Wind Speed (Kmph)
Chennai	Chennai	70
Ranipet	Kalavai	61
Tiruvallur	Tiruttani_Pto	65
Tiruvallur	Tirur_Kvk	59
Kanchipuram	Katapakkam_Kvk	46
Puducherry	Puducherry	48
Chennai Coast	Meteorological Buoy	84

Table 3: Wind Observations along south Andhra Pradesh coast

Coastal Andhra Pradesh	Date & Time (IST)	Wind speed (kmph)
Araveedu (Prakasam)	09/22:45	37
Kavali	09/22:45	37
Nellore	09/01:15	24

The estimated wind distribution in association with the system is given in **Fig.7**.

(c) Storm surge:

The estimated storm surge at the time of landfall was about 0.5 m above astronomical tide around landfall point (**Fig.8**).

5. Operational Forecast Performance:

i) Genesis Forecast

- First information about likely formation of cyclonic circulation over south Andaman Sea during the week 2nd-8th December, with low probability (1-33%) of it's intensification into a depression (cyclogenesis) was issued in the extended range outlook issued by IMD on 24th November **(Fig. 9 a)**.

- Subsequent information about likely formation of depression (cyclogenesis) with high confidence (68-100%) around 6th-7th December was indicated in the extended range outlook issued on 1st December **(Fig. 9 b)**.

- The daily guidance issued under tropical cyclone forecasting programme (TCFP) at 1200 UTC of 29th November indicated likely cyclogenesis over the BoB around 6th December with low probability (1-33%) about 7 days ahead of cyclogenesis (**Fig. 10**).

ii) Operational track, intensity and landfall forecast performance

The operational track, intensity and landfall point & time forecast errors are presented in **Fig.11-13.**

- First information that the depression over southeast BoB would move west-northwestwards and reach southwest BoB near north Tamil Nadu-Puducherry & adjoining south Andhra Pradesh coasts by 08th December morning was issued in the daily weather bulletin and press release issued by National Weather Forecasting Centre on 1st December (**about 9 and half days prior to landfall**).
- First information about likely intensification of the system into a cyclonic storm was mentioned in the Special Message issued at 1230 hours IST of 5th December on formation of low pressure area over South Andaman Sea (**about 4 and half days prior to landfall**).
- First digital information about the landfall near latitude 12.6°N and longitude 80.2°E, close to Mamallapuram (Mahabalipuram) around midnight (2330 hours IST) of 9th December as a cyclonic storm with maximum sustained wind speed of 35 knots (65-75 kmph gusting to 85 kmph) was mentioned in the Special Message issued at 1300 hrs IST of 6th December on formation of well marked low pressure area (**about 90 hours prior to landfall**).
- Actually, the depression formed in the evening of 6th Dec. And intensified into a cyclonic storm Mandous on 7th December, moved west-northwestwards till 7th December evening (1730

hours IST) and then moving northwestwards it crossed North Tamil Nadu coast near Mahabalipuram near latitude 12.60°N and longitude 80.15°E with maximum sustained wind speed of 65-75 kmph gusting to 85 kmph during 2330 hrs IST of 9th December to 0230 hrs IST of 10th December. **Hence, since beginning the track, landfall point, landfall time and intensity were predicted with absolute accuracy.**

- The track forecast errors for 24, 48 and 72 hrs lead period were 41, 47 and 37 km respectively against the long period average (LPA) errors (2017-21) of 73, 106, and 144 km respectively (**Fig. 11a**). **The error in track forecast were appreciably less than the LPA errors for all lead periods.** The skill in track forecast for 24, 48 and 72 hrs lead period was 68%, 86% and 93% respectively against the long period average (LPA) skill (2017-21) of 65%, 77% and 78% respectively. **Hence, for all lead period, it was a skillful forecast better than LPA** (**Fig. 11b**)**.**

- The landfall point forecast errors for 24, 48 and 72 hrs lead period were 8.5, 15.5, 4.5 km respectively against the LPA errors (2017-21) of 32, 62 and 92 km during 2017-21 respectively (**Fig.12a**). The pre-genesis forecast issued at 0300 UTC of 6th December (about 3.5 days prior to landfall) indicated landfall over Tamil Nadu coast with almost **zero error** in landfall point and time. **Thus, there was almost negligible error in landfall point forecast.**

- The landfall time forecast errors for 24, 48 and 72 hrs lead period were 1.0, 2.5 and **zero** hours respectively against the LPA errors (2017-21) of 2.5, 5.0 and 8.3 hours during 2017-21 respectively (**Fig.12b**). **For all lead periods, the landfall time errors were appreciably less than LPA errors.**

- The absolute error (AE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 2.9, 3.8 and zero knots against the LPA errors of 7.8, 11.5 and 14.2 knots during 2017-21 respectively (**Fig.13a**). **The error in intensity forecast were appreciably less than the LPA errors for all lead periods.** The skill based on AE in intensity forecast for 24, 48 and 72 hrs lead period was 82%, 85% and 100% against the LPA skill of 55%, 74% and 77% during 2017-21 respectively (**Fig.13 b**). **The skill in intensity forecast was appreciably better than the LPA for all lead periods.**

- The root mean square (RMSE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 4.3, 5.0 and zero knots against the LPA errors of 15.2, 13.8 and 16.7 knots during 2017-21 respectively (**Fig.13 c**). **The error in intensity forecast were appreciably less than the LPA errors for all lead periods.** The skill based on RMSE in intensity forecast for 24, 48 and 72 hrs lead period was 81%, 84% and 100% against the LPA skill of 42%, 61% and 73% during 2017-21 respectively (**Fig.13 d**). **The skill in intensity forecast was appreciably better than the LPA for all lead periods.**

- Typical observed and forecast track based on 0830 hours IST/0300 UTC of 6th December on formation of well marked low pressure area (**about 90 hours prior to landfall**) demonstrating accuracy in operational forecast is presented in **Fig. 14**.

iii) Adverse weather forecast performance:

(a) Heavy Rainfall warning performance

Date/time (UTC)	Forecast heavy rainfall	Realized heavy rainfall
29-11-2022 /0300	❖ Isolated heavy falls over Andaman & Nicobar (AN) Islands on 4th & 5th December, 2022.	Light to moderate rainfall at most places with • isolated heavy to very heavy rainfall occurred over Andaman and Nicobar Islands on 5th and 6th December, • isolated heavy to very heavy rainfall occurred over north Tamil Nadu, Rayalaseema and south coastal Andhra Pradesh on 8th • isolated heavy to very heavy rainfall at a few places and isolated extremely heavy rainfall occurred over north Tamil Nadu, Puducherry, Rayalaseema and south coastal Andhra Pradesh on 9th • isolated heavy to very heavy rainfall over
30-11-2022 /0300	❖ Isolated heavy falls over A&N Islands from 05th Dec., 2022.	
01-12-2022 /0300	❖ Isolated heavy falls over Nicobar Islands on 04th and over A&N Islands on 05th Dec., 2022.	
02-12-2022 /0300	❖ Isolated heavy falls over Nicobar Islands on 04th and over A&N Islands on 05th Dec., 2022. ❖ Enhanced rainfall activity to commence over north coastal Tamil Nadu, Puducherry & Karaikal and South coast Andhra Pradesh(AP) from 07th Dec. mid-night.	
03-12-2022 /0300	❖ Isolated heavy falls over Nicobar Islands on 04th and over A&N Islands on 05th December, 2022. ❖ Isolated heavy to very heavy rainfall over north Tamilnadu & Puducherry and adjoining south AP on 08th December.	
04-12-2022 /0300	❖ Isolated heavy falls over A&N Islands during 04th-06th December, 2022. ❖ Isolated heavy to very heavy rainfall over north Tamilnadu & Puducherry and isolated heavy rainfall over south AP on 08th Dec.	
05.12.2022 /0300	❖ Isolated heavy to very heavy falls over A&N Islands on 05th and isolated heavy falls on 06th Dec, 2022. ❖ Isolated heavy rainfall over north coastal Tamilnadu, Puducherry & Karaikal from 07th Dec. mid-night. Heavy to very heavy rainfall at isolated places and extremely heavy rainfall at isolated places over north Tamilnadu & Puducherry on 08th Dec. and isolated heavy to very heavy rainfall over Tamilnadu on 9th Dec. ❖ Isolated heavy rainfall to commence over south AP from 07th Dec. mid-night. Isolated heavy to very heavy rainfall on 08th Dec. and isolated heavy rainfall on 9th Dec. over south AP.	
06.12.2022 /0300	❖ Isolated heavy falls over A&N Islands on 06th Dec., 2022. ❖ Heavy to very heavy falls at isolated places over coastal Tamilnadu, Puducherry & Karaikal and adjoining areas off south coastal AP on 8th Dec. ❖ Heavy to very heavy rainfall at a few places and extremely heavy rainfall at isolated places over north coastal Tamilnadu, Puducherry and adjoining south Coastal AP and isolated heavy to very heavy rainfall over north interior Tamilnadu and adjoining Rayalaseema on 9th Dec. ❖ Heavy to very heavy rainfall at isolated places over north Tamilnadu and Rayalaseema and south AP on 10th Dec.	
07.12.2022 /0300	❖ 08th Dec:- Heavy to very heavy falls at isolated places over coastal Tamilnadu, Puducherry & Karaikal and isolated heavy rainfall over adjoining areas of south coastal AP and	

	Rayalaseema. ❖ 09th Dec:- Heavy to very heavy rainfall at a few places and extremely heavy rainfall at isolated places over north coastal Tamilnadu, Puducherry and adjoining south Coastal AP and isolated heavy to very heavy rainfall over north interior Tamilnadu and adjoining Rayalaseema on 09th Dec. ❖ 10th December:- Heavy to very heavy rainfall at isolated places over north Tamilnadu and Rayalaseema and south AP on 10th Dec.	south coastal Andhra Pradesh and isolated heavy rainfall over north Tamil Nadu, Rayalaseema, south Interior Karnataka and Kerala on 10th.
08.12.2022 /0300	❖ 08th Dec:- Heavy to very heavy falls at isolated places very likely over coastal Tamil Nadu, Puducherry & Karaikal and isolated heavy rainfall over adjoining areas of south coastal AP & Rayalaseema. ❖ 09th Dec:- Heavy to very heavy rainfall at a few places and extremely heavy rainfall at isolated places over north coastal Tamil Nadu, Puducherry and isolated heavy to very heavy rainfall over adjoining south Coastal AP and north interior Tamilnadu and Rayalaseema. ❖ 10th Dec:- Heavy to very heavy rainfall at isolated places over north Tamil Nadu and Rayalaseema and south AP.	
09.12.2022 /0300	❖ 09th Dec: - Heavy to very heavy rainfall at a few places and extremely heavy rainfall at isolated places very likely over north coastal Tamil Nadu, Puducherry and isolated heavy to very heavy rainfall over adjoining south Coastal AP and north interior Tamilnadu and Rayalaseema. ❖ 10th Dec:- Heavy to very heavy rainfall at isolated places over north interior Tamil Nadu and Rayalaseema and adjoining south AP.	
10.12.2022 /0300	❖ 10th Dec:- Heavy to very heavy rainfall at isolated places over Rayalaseema, north Tamil Nadu and south interior Karnataka	

(b) Wind Warning performance:

Date/Time in UTC	Forecast Wind	Realized Wind
01.12.2022 /0300	❖ **40-45 kmph gusting to 55 kmph** over Andaman & Nicobar (A&N) Islands, Andaman sea & adjoining Southeast(SE) BoB on 04th Dec. ❖ **45-55 kmph gusting to 65 kmph** over A&N Islands and SE BoB and **40-45 gusting to 55 kmph** over SE BoB & adjoining Andaman Sea 05th Dec.	**A& N Islands:** 30 to 40 kmph gusting to 50 kmph **South coastal Andhra Pradesh:** 40-50 gusting to 60 kmph **North Tamil Nadu & Puducherry:** 65-75 kmph
02.12.2022 /0300	❖ 40-45 kmph gusting to 55 kmph over A&N Islands and Andaman Sea & adjoining SE BoB on 04th Dec. **45-55 gusting to 65 kmph** over A&N Islands; SE BoB & adjoining Andaman Sea on 05th & **45-55 gusting to 65 kmph** over Southwest(SW) & adjoining SE BoB on 06th.	
03.12.2022 /0300	❖ 40-45 gusting to 55 kmph over A&N Islands and Andaman Sea on 04th & 05th Dec. ❖ 45-55 gusting to 65 kmph over SE BoB on 05th & 06th Dec.; over SW & adjoining SE BoB on 06th & 7th Dec.	

	❖ 50-60 gusting to 70 kmph over SW BoB & adjoining Sri Lanka coast on 07th & 08th Dec. ❖ 40-50 gusting to 60 kmph along & off Tamilnadu, Puducherry and South Andhra Pradesh(AP) coast from 08th Dec. morning becoming 50-60 gusting to 70 kmph from 08th Dec. evening for subsequent 12 hours.	gusting to 85 kmph **South Tamil Nadu & Gulf of Mannar:** 45-55 kmph gusting to 65 kmph
04.12.2022 /0300	❖ 40-45 gusting to 55 kmph over A&N Islands and Andaman Sea on 04th & 05th Dec. ❖ 45-55 gusting to 65 kmph over SE BoB on 05th & 06th Dec.; over SW & adjoining SE BoB on 06th & 7th Dec. ❖ 50-60 gusting to 70 kmph over SW BoB & adjoining Sri Lanka coast on 07th & 08th Dec. ❖ 40-50 gusting to 60 kmph along & off Tamilnadu, Puducherry, south AP coast and Gulf of Mannar from 08th Dec. morning becoming 50-60 kmph gusting to 70 kmph from 08th December evening for subsequent 12 hours.	
05.12.2022 /0300	❖ **40-45 gusting to 55 kmph** over A&N Islands and Andaman Sea on 05th & 06th December. ❖ **45-55 gusting to 65 kmph** over SE BoB during 05th to 7th December ❖ **45-55 gusting to 65 kmph** over SW BoB on 6th. It would increase gradually becoming **55-65 gusting to 75 kmph** on 7th and Gale wind speed reaching **70-80 kmph gusting to 90 kmph** over the same region on 08th. It would decrease thereafter gradually. ❖ **40-50 gusting to 60 kmph** likely to commence along & off Tamilnadu, Puducherry, south AP and north Sri Lanka coasts coast from 08th Dec. morning becoming **60-70 gusting to 80 kmph** from 08th Dec. evening to 9th Dec. morning. It is likely to reduce to **45-55 gusting to 65 kmph** by 09th Dec. evening. ❖ **40-50 gusting to 60 kmph** to prevail over Gulf of Mannar during 7th-9th Dec.	
06.12.2022 /0300	❖ **40-45 gusting to 55 kmph** over A&N Islands and Andaman Sea on 06th Dec. ❖ **45-55 gusting to 65 kmph** over SE BoB on 06th and it would increase gradually becoming **50-60 gusting to 70 kmph** on 7th Dec. and then reduce to **40-45 gusting to 55 kmph on 8th Dec**. ❖ **40-50 kmph gusting to 60 kmph** over SW BoB on 6th. It would increase gradually becoming **50-60 gusting to 70 kmph** from 7th morning and Gale wind speed reaching **70-80 gusting to 90 kmph** over the same region on 08th and 9th. It would decrease thereafter gradually. ❖ **40-50 gusting to 60 kmph** to commence along & off Tamilnadu, Puducherry, south AP and north Sri Lanka coasts coast from 08th Dec. morning becoming **50-60 gusting to 70 kmph** from 08th Dec. evening, **70-80 gusting to 90 kmph** from 09th Dec. evening to 10th Dec. morning. It would reduce gradually to **50-60 gusting to 70 kmph** by afternoon of 10th Dec. evening and then to **40-50 gusting to 60 kmph** by 10th Dec. night. ❖ **40-50 gusting to 60 kmph** over Gulf of Mannar from	

	08th Dec. evening becoming **50-60 gusting to 70 kmph** from 09th Dec. evening to 10th Dec. morning. It is likely to reduce gradually thereafter.	
07.12.2022 /0300	❖ **50-60 gusting to 70 kmph,** over SE BoB during next 24 hours and then reduce to **40-45 gusting to 55 kmph on 8th Dec**. ❖ **50-60 gusting to 70 kmph** prevailing over SW BoB, would increase gradually becoming 6**0-70 gusting to 80 kmph** from 7th evening. It would further increase becoming Gale wind, speed reaching **70-80 gusting to 90 kmph,** over the region from 8th morning and **80-90 kmph gusting to 100 kmph** during 08th evening to 09th morning. It would decrease thereafter gradually. ❖ **40-50 gusting to 60 kmph,** likely to commence along & off Tamilnadu, Puducherry, south Andhra Pradesh and north Sri Lanka coasts coast from 08th Dec morning, becoming **50-60 gusting to 70 kmph** from 08th Dec. evening, **70-80 gusting to 90 kmph** from 09th Dec. evening to 10th Dec. morning. It is likely to reduce gradually to **50-60 kmph gusting to 70 kmph** by afternoon of 10th Dec. and then to **40-50 gusting to 60 kmph** by 10th Dec. night. ❖ **40-50 gusting to 60 kmph,** likely over Gulf of Mannar from 08th Dec. evening becoming **50-60 gusting to 70 kmph** from 09th Dec. evening to 10th Dec. morning. It is likely to reduce gradually thereafter.	
08.12.2022 /0300	❖ **SW BoB:-** 75-85 kmph gusting to 95 kmph is prevailing. It would further increase becoming 80-90 gusting to 100 kmph, during 08th noon to 08th night. It would decrease thereafter gradually becoming 75-85 gusting to 95 kmph, from 9th morning and 70-80 gusting to 90 kmph from 9th Dec. evening. ❖ **Along & off Tamil Nadu, Puducherry, south AP and north Sri Lanka coasts:-** 40-50 kmph gusting to 60 kmph, likely to commence from 08th Dec. afternoon, becoming 50-60 kmph gusting to 70 kmph from 9th Dec. morning and 65-75 kmph gusting to 85 kmph from 09th Dec. evening to early hours of 10th Dec. It is likely to reduce gradually thereafter becoming 55-65 gusting to 75 kmph by morning of 10th Dec. and then to 30-40 kmph gusting to 50 kmph by 10th Dec. night. ❖ **Gulf of Mannar :-** 40-50 gusting to 60 kmph, from 08th Dec. evening becoming 50-60 gusting to 70 kmph from 09th Dec. evening to early hours of 10th Dec. and 40-50 kmph gusting to 60 kmph by 10th Dec. morning. ❖ **SE BoB:-** 40-45 gusting to 55 kmph, is likely to prevail on 8th Dec.	
09.12.2022 /0300	❖ **SW BoB:-** 80-90 gusting to 100 kmph is prevailing. It would decrease gradually becoming 70-80 gusting to 90 kmph from today evening, 55-65 kmph gusting to 75 kmph by 10th Dec. early morning and 30-40 gusting to 50 kmph by 10th Dec. evening. ❖ **Along & off Tamil Nadu, Puducherry, south AP and north Sri Lanka coasts:-** 45-55 gusting to 65 kmph is	

	prevailing. It would increase and become 50-60 gusting to 70 kmph by today afternoon and 65-75 gusting to 85 kmph from today, the 09th Dec. evening till early hours of 10th Dec. It is likely to reduce gradually thereafter becoming 55-65 gusting to 75 kmph by morning of 10th December and then to 30-40 gusting to 50 kmph by 10th Dec. evening. ❖ **Gulf of Mannar:-** 40-50 gusting to 60 kmph is prevailing. It would increase and becoming 50-60 gusting to 70 kmph from today evening to early hours of 10th December and 40-50 gusting to 60 kmph by 10th December morning. ❖ **Westcentral BoB** off south AP coast**:-** 40-50 gusting to 60 kmph is likely to prevail till noon. It would increase gradually becoming 55-65 gusting to 75 kmph from today, the 9th Dec evening to 10th Dec early morning and reduce thereafter gradually becoming 30-40 gusting to 50 kmph by 10th Dec evening.	
10.12.2022 /0300	❖ **SW BoB and along & off Tamil Nadu, Puducherry and south AP coasts:-** 50-60 gusting to 70 kmph likely to prevail till noon and to reduce thereafter becoming 30-40 gusting to 50 kmph by 10th December evening.	

(c) Storm surge Warning performance:

The estimated realised storm surge was 0.45 metre **(Fig.8)** along the north Tamil Nadu coast around the time of landfall against the predicted storm surge of 0.4 to 0.6 metre.

7. Warnings and advisories issued

Bulletins issued by Cyclone Warning Division, New Delhi

- **Track, intensity and landfall forecast:** IMD continuously monitored, predicted and issued bulletins containing track, intensity, and landfall forecast for +06, +12, +18, +24, +36 and +48… +96 hrs lead period commencing from 6th December morning (0830 hours IST/0300 UTC) till the system weakened into a low pressure area. The above forecasts were issued from the stage of well marked low pressure area onwards along with the cone of uncertainty in the track forecast five times a day and every three hours during the cyclone period.
- **Cyclone structure forecast for shipping and coastal hazard management:** The radius of maximum wind and radii of MSW ≥28, ≥34 and ≥50 knots wind in four quadrants of cyclone was issued every six hourly, commencing from 6th December evening (0830 hours IST/0300 UTC) giving forecast for +06, +12, +18, +24, +36 and +96 hrs lead period.

- **Four stage Warning:**
  - ❖ Considering the development of cyclonic storm over westcentral BoB, IMD issued first Special Message and Press Release daily since 5th Dec. on formation of low pressure area over south Andaman Sea. It was also indicated that the system would intensify into a cyclonic storm and reach southwest Bay of Bengal off north Tamil Nadu, Puducherry and south Andhra Pradesh coast by 8th.
  - ❖ Special Message and Press Release were further updated on 06th Dec. forenoon with formation of well marked low pressure area and **Pre cyclone watch** for north Tamil Nadu, Puducherry and south Andhra Pradesh coasts (**about 84 hrs prior to landfall**)

indicating expected landfall point, time and intensity and expected adverse weather like extremely extremely heavy rainfall, wind of 65-75 kmph gusting to 85 kmph and storm surge of about 0.5 metre, expected damages and required response actions.

- ❖ **National crisis management committee (NCMC) meeting** was held on 6th December and DG IMD made the presentation with participation of concerned states and central agencies under the chairmanship of Cabinet Secretary.
- ❖ **Cyclone Alert** for north Tamil Nadu, Puducherry and south Andhra Pradesh coasts was issued in the morning of 7th December with further updates on warning (**about 63 hours prior to landfall**)
- ❖ **Cyclone Warning** for north Tamil Nadu, Puducherry and south Andhra Pradesh coasts was issued in the afternoon of 8th December at 1430 hrs IST **(about 34 hours prior to landfall**).

- **Adverse weather warning bulletins:** The tropical cyclone forecasts alongwith expected adverse weather like heavy rain, gale wind and state of sea was issued with every six/three hourly update to central, state and district level disaster management agencies including Ministry of Home Affairs (MHA), National disaster Response Force (NDRF), National Disaster management Agency (NDMA) for all concerned states along the east coast of India including Administrator Andaman & Nicobar Islands, Tamil Nadu & Puducherry, Andhra Pradesh, West Bengal and Odisha. The bulletins also contained the suggested action for disaster managers and general public in particular for fishermen, ports and off & along shore activities. These bulletins were also issued to Defence including Indian Navy & Indian Air Force, NDRF, Indian Coast Guard, ports, Shipping, fishery, Railways, surface transport and aviation authorities.
- **Warning graphics:** The graphical display of the observed and forecast track with cone of uncertainty and the wind forecast for different quadrants were disseminated by email and uploaded in the RSMC, New Delhi website (http://rsmcnewdelhi.imd.gov.in/) regularly. The adverse weather warnings related to heavy rain, gale wind & fishermen warnings were also presented in graphics alongwith colour codes in the website.
- **Warning and advisory through social media:** Daily updates (every three hourly or whenever there was any significant change in intensity/track/landfall) were uploaded on Facebook and Twitter during the life period of the system since the emergence of low pressure area into Andaman Sea.
- **Press Conference, Press release and Media briefing:** Press and electronic media were given daily updates since inception of system through press release, e-mail, website, video capsule by DGM and SMS.
- **Warning and advisory for marine community:** The three/six hourly Global Maritime Distress Safety System (GMDSS) bulletins were issued by the Marine Weather Services Division at New Delhi and bulletins for maritime interest were issued by Area cyclone warning centres of IMD at Kolkata and Area Cyclone Warning Centre at Chennai, Cyclone warning centres at Visakhapatnam and Bhubaneswar to ports, fishermen, coastal and high sea shipping community.
- **Fishermen Warning:** Regular warnings for fishermen for deep Sea of Bay of Bengal were issued since 1st December.
- **Advisory for international Civil Aviation:** The Tropical Cyclone Advisory Centre (TCAC) bulletin for International Civil Aviation were issued every six hourly to all meteorological watch offices in Asia Pacific region for issue of significant meteorological information (SIGMET). It was also sent to Aviation Disaster Risk Reduction (ADRR) centre of WMO at Hong Kong.
- **Diagnostic and prognostic features of cyclone:** The prognostics and diagnostics of the systems were described in the RSMC bulletins.
- **Director General of Meteorology** gave a presentation on the status of SCS Mandous during the National Crisis Management Committee Meeting chaired by Hon'ble Cabinet Secretary.

Statistics of bulletins issued by RSMC New Delhi, Area Cyclone Warning Centre Chennai, Meteorological Centre Amrawati in association with the SCS Mandous are given in **Table 4-5.**

Table 4: Bulletins issued by Cyclone Warning Division, New Delhi

S.No	Bulletin type	No. of Bulletins	Issued to
1	National Bulletin	29	1. IMD's website, RSMC New Delhi website 2. FAX and e-mail to Control Room Ministry of Home Affairs & National Disaster Management Authority, Cabinet Secretariat, Minister of Science & Technology, Secretary MOES, Headquarter Integrated Defense Staff, Director General Doordarshan, All India Radio, PIB MOES, DG National Disaster Response Force, Director, Punctuality, Indian Railways, Chief Secretary: Government of Administrator Andaman & Nicobar Islands, Tamil Nadu & Puducherry, Andhra Pradesh, West Bengal and Odisha.
2.	Special Message	2	1. IMD's website, RSMC New Delhi website 2. FAX and e-mail to Control Room Ministry of Home Affairs & National Disaster Management Authority, Cabinet Secretariat, Minister of Science & Technology, Secretary MOES, Headquarter Integrated Defense Staff, Director General Doordarshan, All India Radio, PIB MOES, DG National Disaster Response Force, Director, Punctuality, Indian Railways, Chief Secretary: Government of Administrator Andaman & Nicobar Islands, Tamil Nadu & Puducherry, Andhra Pradesh, West Bengal and Odisha.
3	Bulletin from DGM IMD	4	FAX and e-mail to Cabinet Secretary, Prime Minister office, Control Room Ministry of Home Affairs & National Disaster Management Authority, Minister of Science & Technology, Secretary MOES, Headquarter Integrated Defense Staff, Director General Doordarshan, All India Radio,PIB MOES,UNI,DG National Disaster Response Force,Director, Punctuality, INDIAN RAILWAYS, Chief Secretary: Government of Administrator Andaman & Nicobar Islands, Tamil Nadu & Puducherry, Andhra Pradesh, West Bengal and Odisha.
	Hourly bulletins on the day of landfall	11	1. IMD's website, RSMC New Delhi website 2. FAX and e-mail to Control Room Ministry of Home Affairs & National Disaster Management Authority, Cabinet Secretariat, Minister of Science & Technology, Secretary MOES, Headquarter Integrated Defense Staff, Director General Doordarshan, All India Radio, PIB MOES, DG National Disaster Response Force, Director, Punctuality, Indian Railways, Chief Secretary: Government of Administrator Andaman & Nicobar Islands, Tamil Nadu & Puducherry, Andhra Pradesh, West Bengal and Odisha.
4	RSMC Bulletin	28 + 5 tropical weather outlook	1. IMD's website 2. WMO/ESCAP member countries through GTS and E-mail.
5	GMDSS Bulletins	22	1. IMD website, RSMC New Delhi website 2. Transmitted through WMO Information System (WIS) to Joint WMO/IOC Technical Commission for Ocean and Marine Meteorology (JCOMM)
6	Tropical Cyclone Advisory Centre Bulletin	12	1. Met Watch offices in Asia Pacific regions and middle east through GTS to issue Significant Meteorological information for International Civil Aviation 2. WMO's Aviation Disaster Risk Reduction (ADRR), Hong Kong through ftp 3. RSMC website

7	Tropical Cyclone Vital Statistics	12	Modelling group of IMD, National Centre for Medium Range Weather Forecasting Centre (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS), Indian Institute of Technology (IIT) Delhi, IIT Bhubaneswar etc.
8	Warnings through Social Media	6 hourly (depression stage)/3 hourly (cyclonic storm stage) /hourly (landfall day)	Cyclone Warnings were uploaded on Social networking sites (Facebook and Tweeter) since inception to weakening of system (every time when there was change in track, intensity and landfall characteristics).
9	Press Release	6	Disaster Managers, Media persons by email and uploaded on website
10	Press Briefings	Daily	Regular briefing daily
11	Bulletins for offshore industries	22	6 hourly during depression and 3 hourly during cyclonic storm by email to offshore industries, Directorate General of Hydrocarbons, Coast Guard
12	SMS	Frequently	**5,55,231** to general public and disaster managers registered through RSMC website
13	Whatsapp Messages	6 hourly (depression stage)/3 hourly (cyclonic storm stage) /hourly (landfall day)	To Disaster management group, Media Group, WMO and WMO/EsCAP Panel member countries group and Offshore industries group.

Table 5: Statistics of bulletins issued by Area Cyclone Warning centre (ACWC) Chennai and Meteorological Centre (MC) Amravati.

S.No.	Type of Bulletin	No. of Bulletins issued by	
		ACWC Chennai	MC Amravati
1.	Sea Area Bulletins	11	CWC Visakhapatnam
2.	Coastal Weather Bulletins	12	CWC Visakhapatnam
3.	Fishermen Warnings issued	18	14
4.	Port Warnings	7	CWC Visakhapatnam
5.	Heavy Rainfall Warning	15	70
6.	Gale Wind Warning	15	70
7.	Storm Surge Warning	10	7
8.	Warning issued to State Government and other Agencies	20	70 bulletins by email
9.	SMS		2,68,72,467 through CAP through APSDMA via BSNL, Jio, Airtel, Vodafone-Idea
10.	No. of Press releases	16-English; 6-Tamil	7
11.	No. of impact based warnings for a. District b. City	4 districts – impact expected due to heavy rain, gale winds & storm surge 8 districts – impact expected due to gale winds and heavy rain including Chennai city.	7 7

12.	No. of whatsapp messages	38 times to various groups	34,23,213
13.	No. of updates on facebook	40	43
14.	No. of updates on tweeter	52	43 each
15.	No. of Forecast / Warning video released	4	3

ew Initiatives:

- IMD introduced probability of exceedance of 34 knots winds in graphical format since 8th December. A sample graphics is placed at **Fig. 15**.
- Doppler Weather Chennai released 3D analysis of precipitation during landfall of SCS Mandous (**Fig. 16**). The movie loop is available at https://youtu.be/1S2BeFLVVfE).

8. Damage report

As per media reports SCS Mandous caused 4 deaths in Tamil Nadu, 1 in Andhra Pradesh and 3 in Sri Lanka. It caused damage to loose structures, thatched houses and standing crops. Some damage photographs are placed at **Fig. 17**.

9. Acknowledgements:

India Meteorological Department (IMD) and RSMC New Delhi duly acknowledge contribution from WMO and WMO/ESCAP member countries including Sri Lanka, Myanmar and Thailand in dissemination of bulletins and warnings associated with SCS Mandous.

IMD and RSMC New Delhi also acknowledge the contribution from all the stake holders and disaster management agencies who contributed to the successful monitoring, prediction and early warning service of SCS Mandous. We acknowledge the contribution of all sister organisations of Ministry of Earth Sciences including National Centre for Medium Range Weather Forecasting Centre (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS), National Institute of Ocean Technology (NIOT), Indian Institute of Tropical Meteorology (IITM) Pune. The support from various Divisions/Sections of IMD including Area Cyclone Warning Centre (ACWC) Kolkata & Chennai, Cyclone warning Centre Visakhapatnam, Meteorological Office Port Blair, Meteorological Centre Amravati, coastal observatories along the east coast of India and Doppler Weather Divisions at Chennai and Karaikal. The contribution from Numerical Weather Prediction Division, Satellite and Radar Division, Surface & Upper air instruments Divisions, New Delhi and Information System and Services Division at IMD is also duly acknowledged.

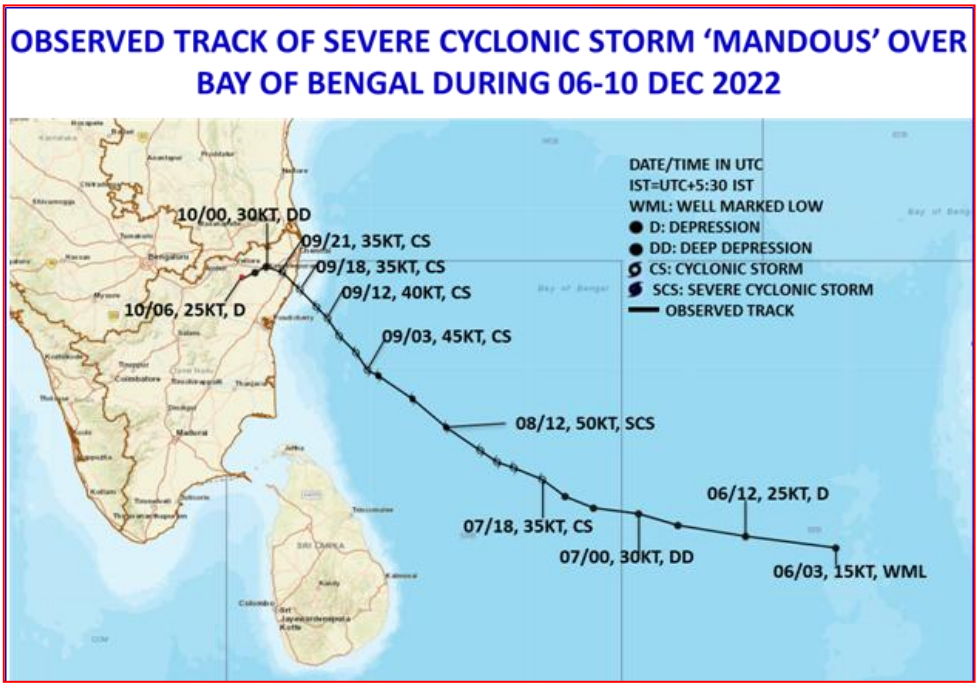


Fig. 1: Observed track of severe cyclonic storm 'MANDOUS" over the BoB during 6th-10th December, 2022

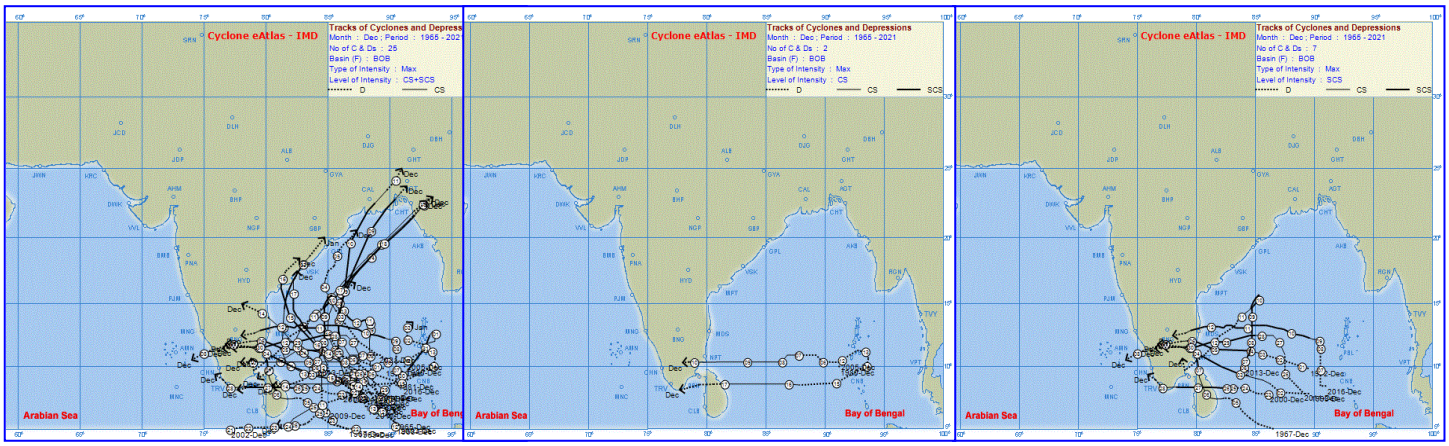


Fig.2: Climatological tracks of (a) all cyclones (MSW≥62 kmph), (b) cyclonic storms (MSW: 62-88 kmph) and (c) severe cyclonic storms (MSW ≥89 kmph) crossing Tamil Nadu coast during satellite era (Dec. 1965-2021)

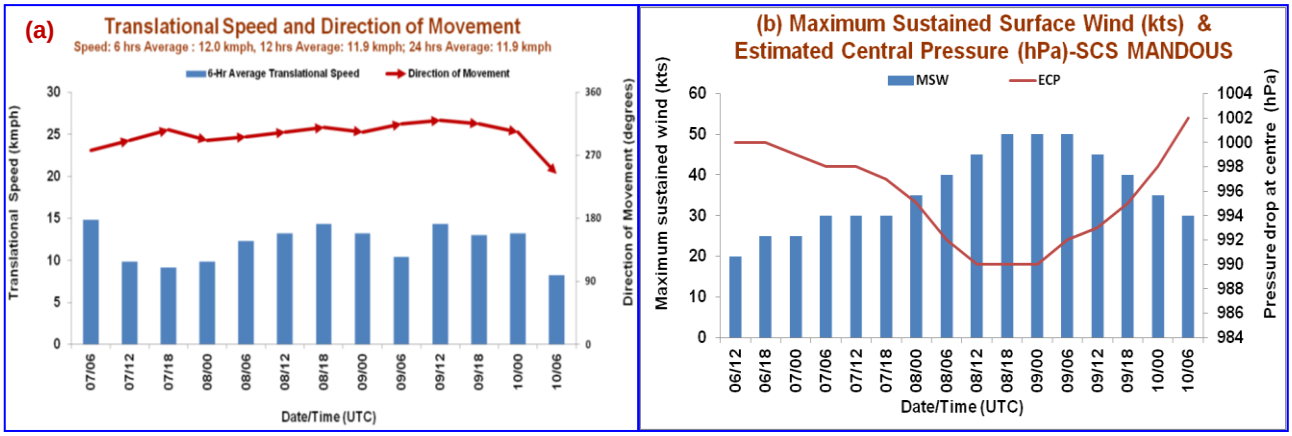


Fig. 3: (a) Past six hourly average translational speed ending at date/time mentioned in the X-axis and direction of movement of severe cyclonic storm 'MANDOUS" over the BoB during 6th-10th December, 2022 and (b) six hourly maximum sustained wind speed and estimated central pressure

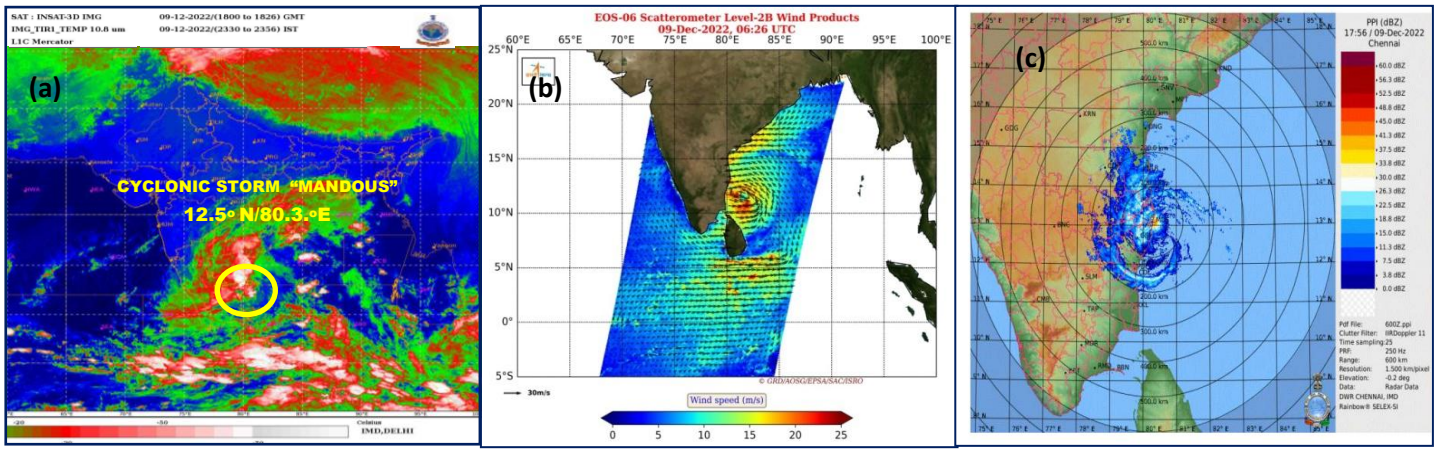


Fig.4: (a) Typical INSAT 3D (R), (b) OSCAT and (c) DWR Chennai imageries

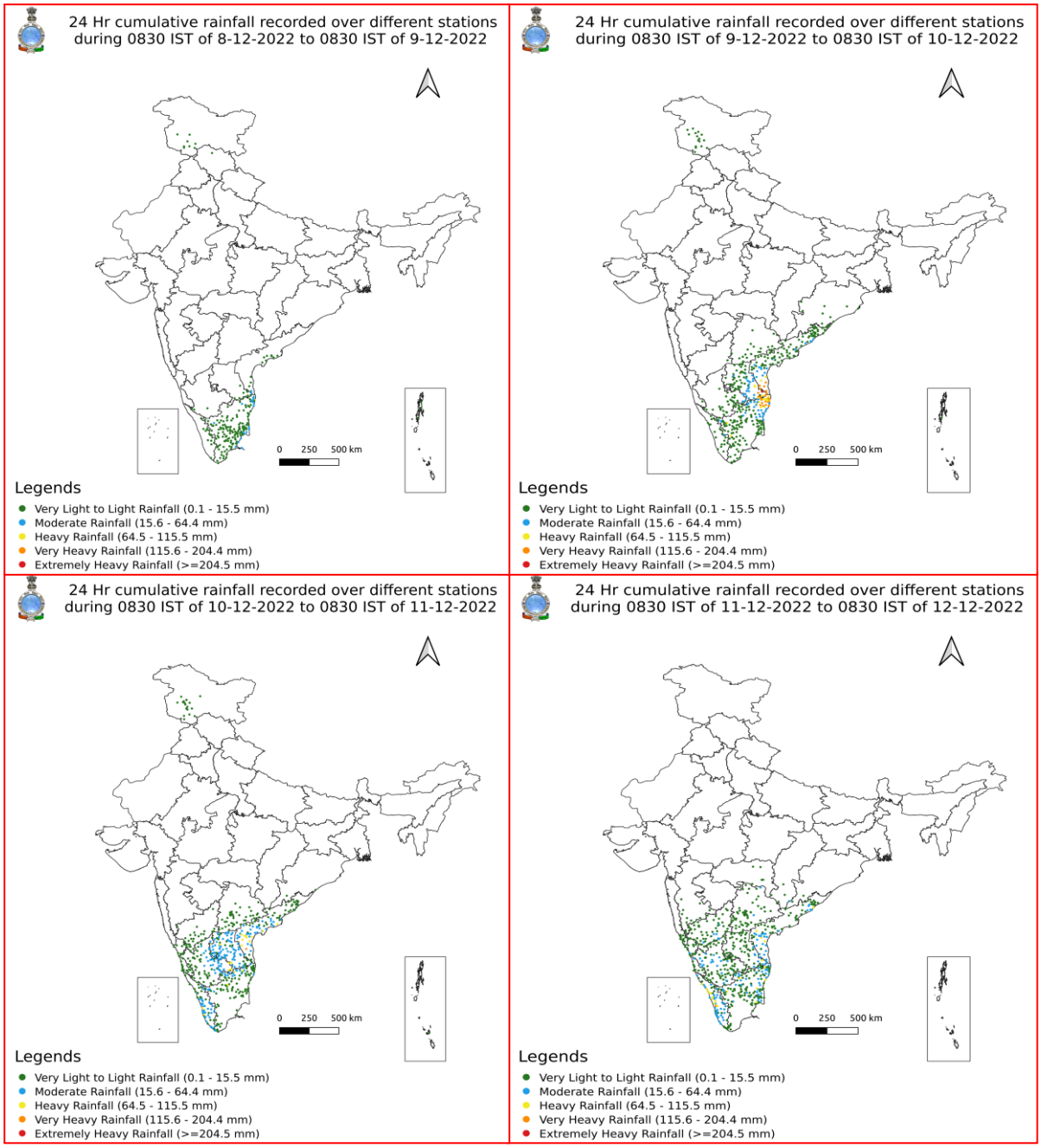


Fig.5: Rainfall recorded over different stations during 7th to 11th Dec. 2022

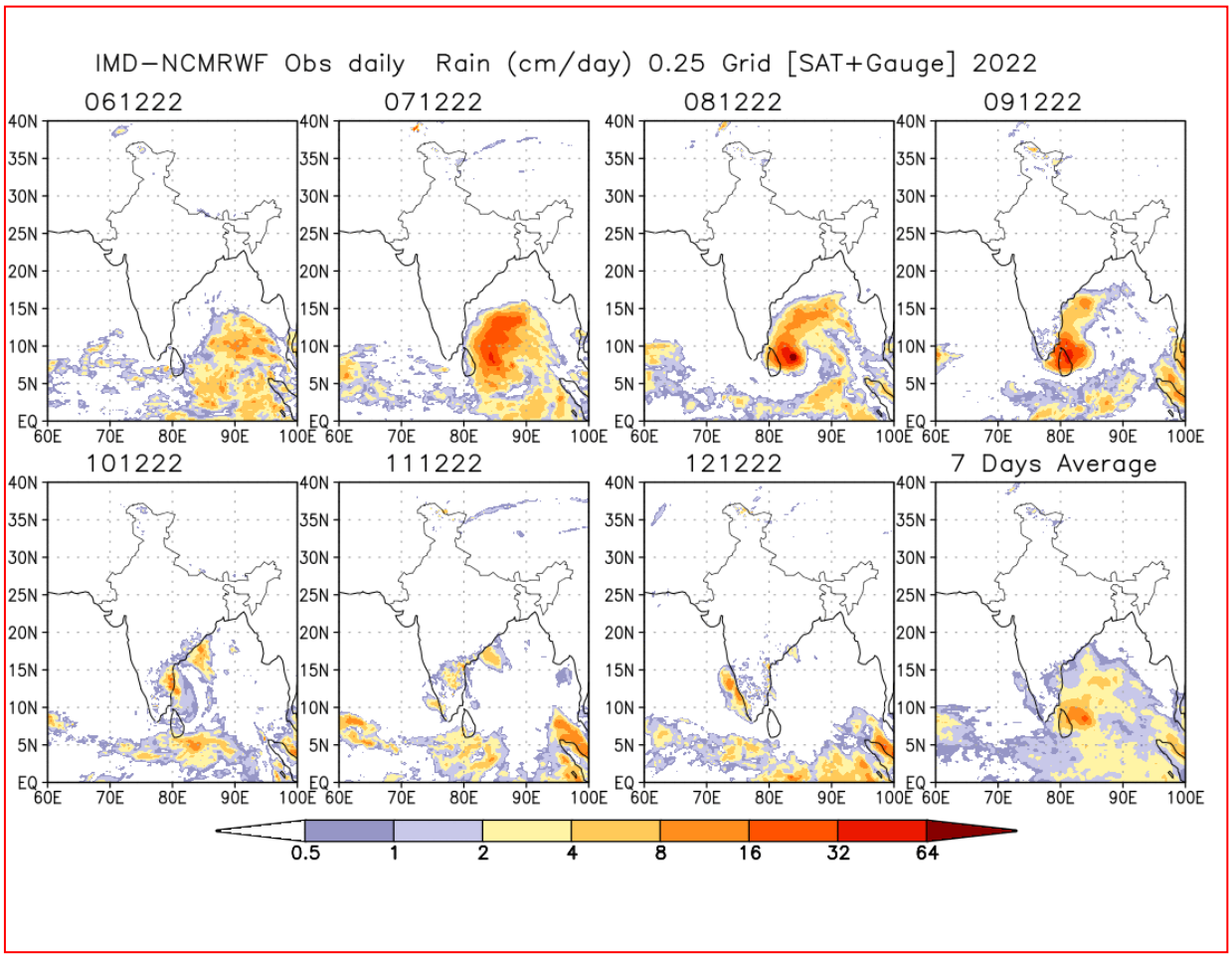


Fig.6: IMD NCMRWF satellite gauge merged plots indicating realised rainfall during past 24 hours ending at 0300 UTC of date.

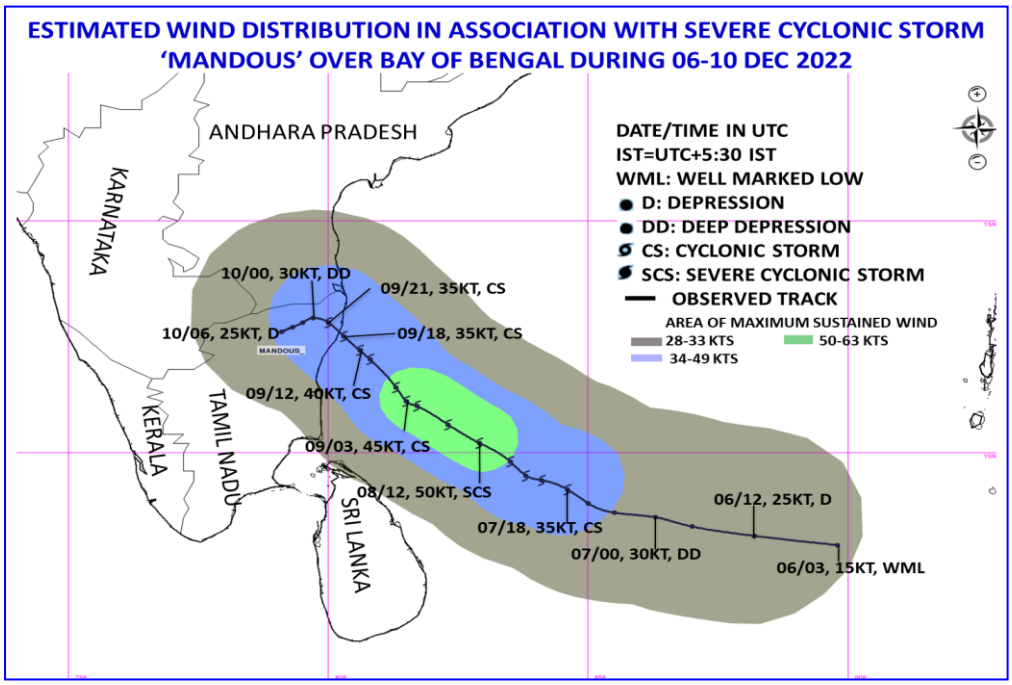


Fig.7: Estimated maximum sustained wind speed distribution in association with SCS, Mandous

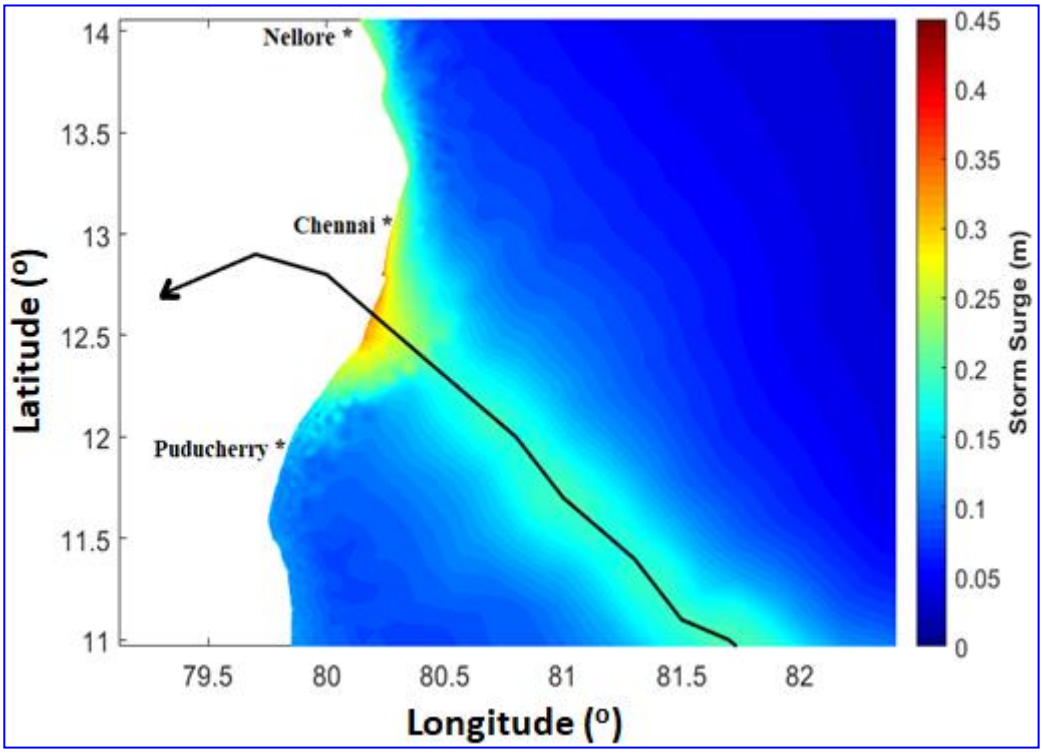


Fig.8: Realised storm surge in association with SCS, Mandous

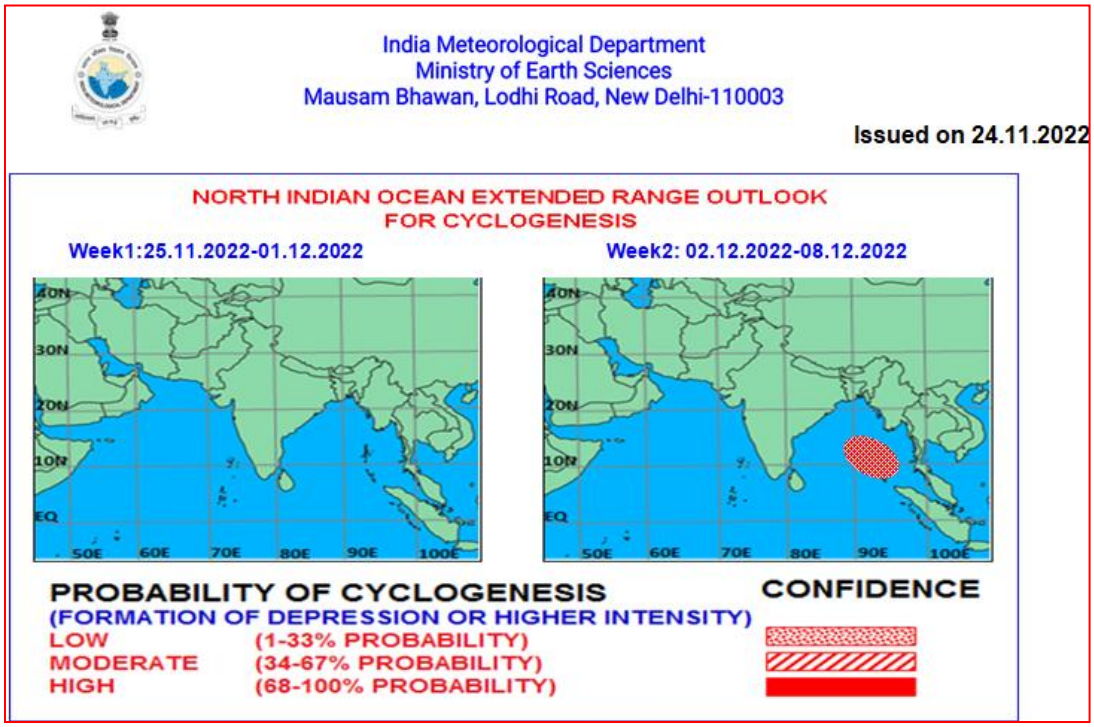


Fig. 9a: Extended range outlook issued on 24th November, 12 days prior to formation of depression on 06th Dec. about 15 days prior to landfall over Tamil Nadu

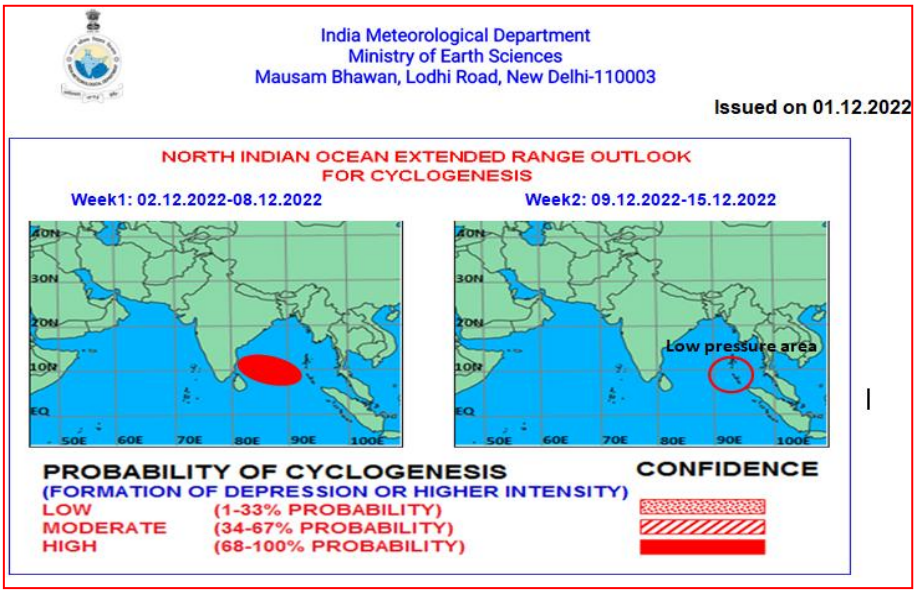
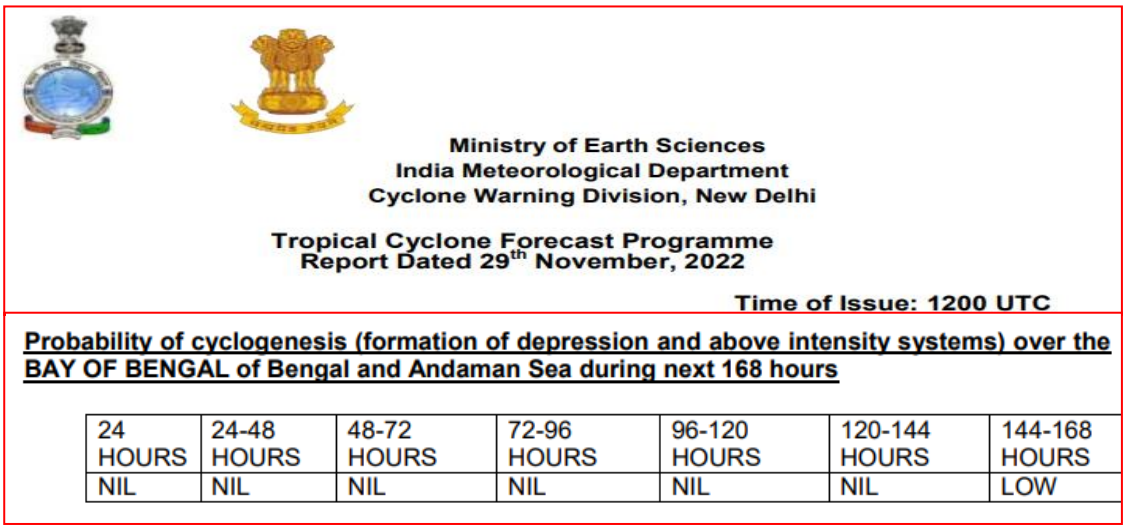


Fig. 9b: Extended range outlook issued on 1st December, 5 days prior to formation of depression on 06th Dec. and about 8 days prior to landfall over Tamil Nadu



Ministry of Earth Sciences
India Meteorological Department
Cyclone Warning Division, New Delhi

Tropical Cyclone Forecast Programme
Report Dated 29th November, 2022

Time of Issue: 1200 UTC

Probability of cyclogenesis (formation of depression and above intensity systems) over the BAY OF BENGAL of Bengal and Andaman Sea during next 168 hours

24 HOURS	24-48 HOURS	48-72 HOURS	72-96 HOURS	96-120 HOURS	120-144 HOURS	144-168 HOURS
NIL	NIL	NIL	NIL	NIL	NIL	LOW

Fig.10: Extract of TCFP guidance issued on 29th November indicating likely formation of depression during 5th-6th December

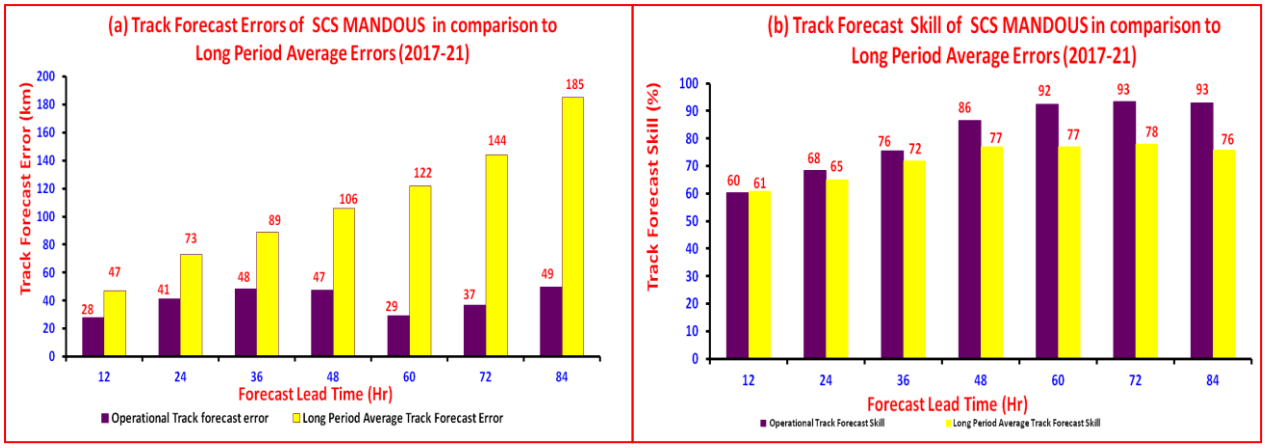


Fig.11: Operational (a) track forecast errors and (b) track forecast skill compared to long period average during 2017-21

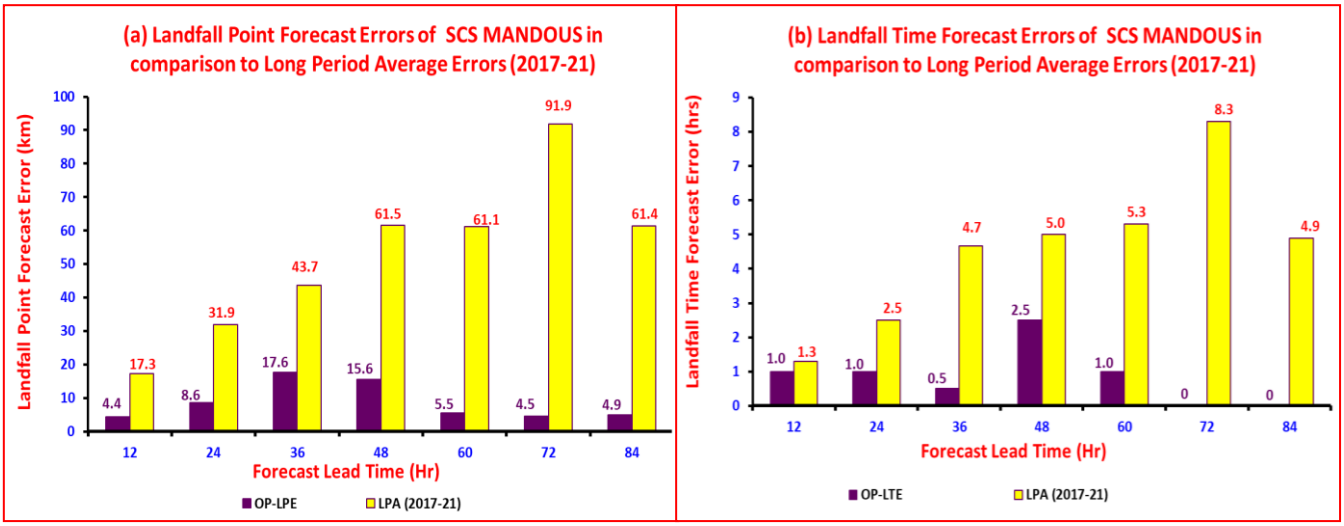


Fig.12: Operational landfall (a) point and (b) time forecast errors and skill compared to long period average during 2017-21

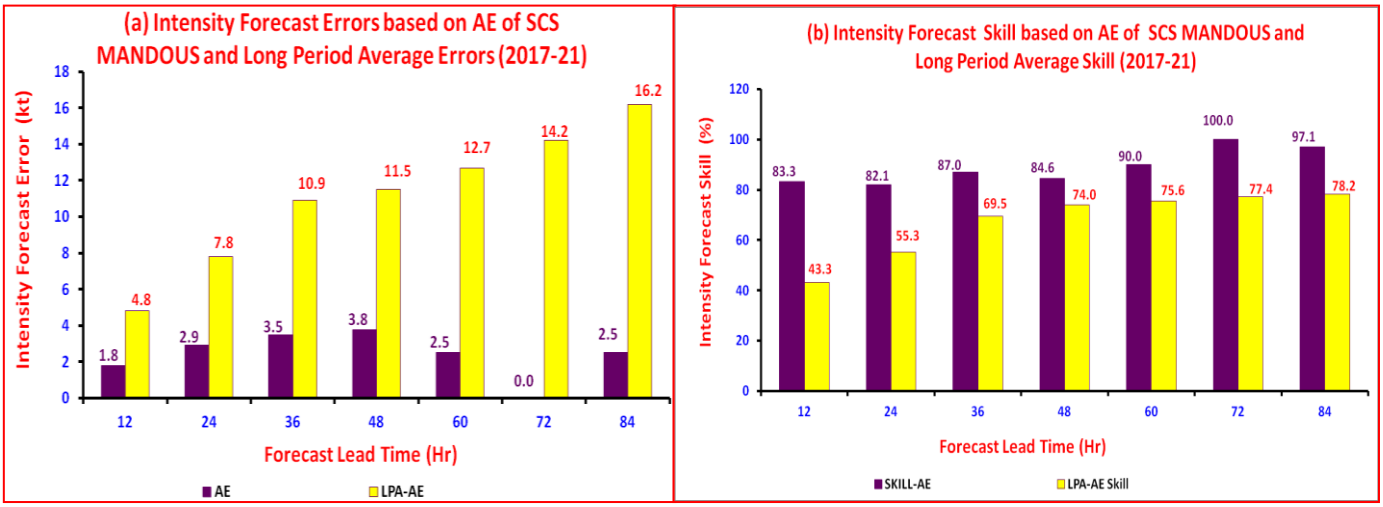


Fig.13(a-b): Operational intensity forecast (a) absolute errors and (b) skill based on compared to long period average during 2017- 21

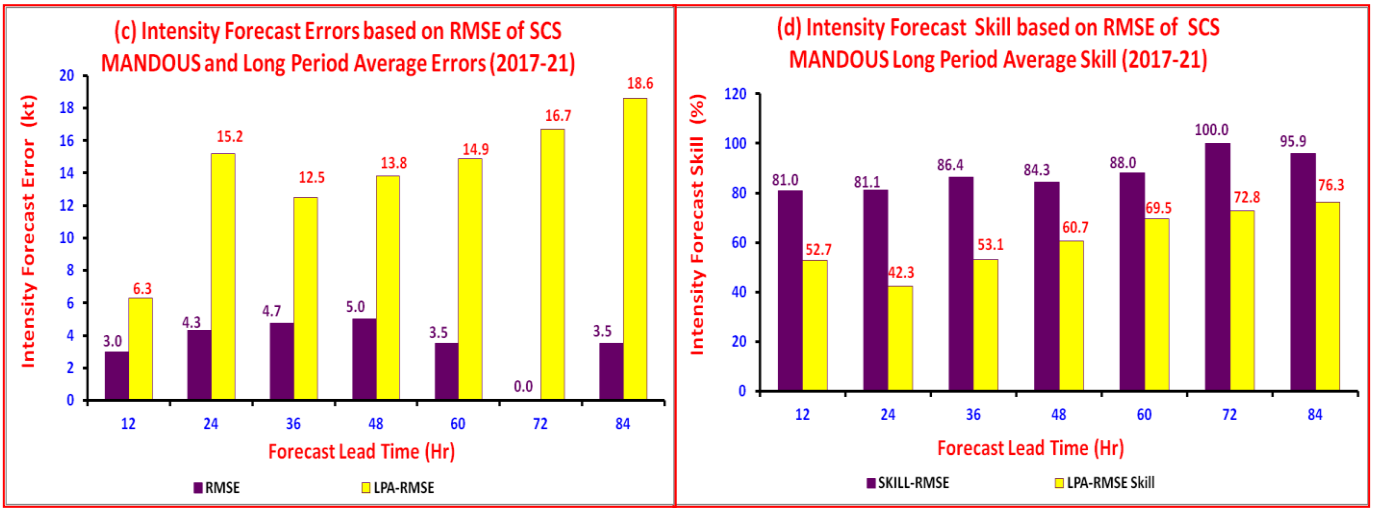
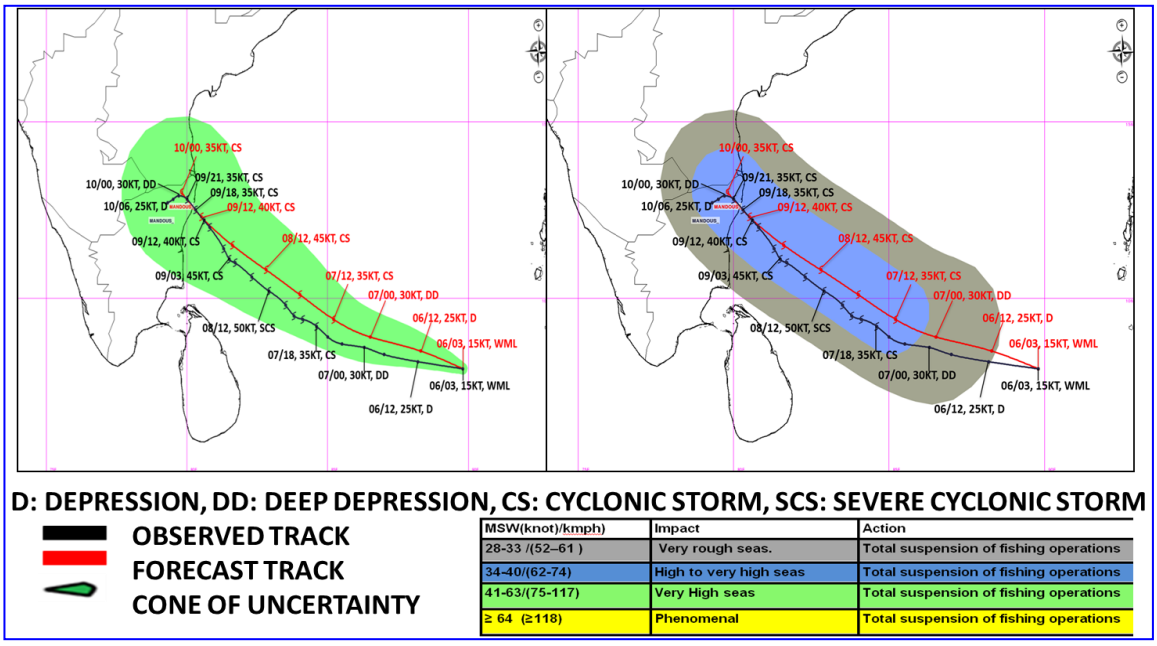


Fig.13(c-d): Operational intensity forecast (c) root mean square errors and (d) skill based on compared to long period average during 2017- 21



D: DEPRESSION, DD: DEEP DEPRESSION, CS: CYCLONIC STORM, SCS: SEVERE CYCLONIC STORM

OBSERVED TRACK
FORECAST TRACK
CONE OF UNCERTAINTY

MSW(knot)/kmph)	Impact	Action
28-33 /(52–61)	Very rough seas.	Total suspension of fishing operations
34-40/(62-74)	High to very high seas	Total suspension of fishing operations
41-63/(75-117)	Very High seas	Total suspension of fishing operations
≥ 64 (≥118)	Phenomenal	Total suspension of fishing operations

Fig.14: Observed and forecast track issued at 0830 hours IST of 6th December (90 hours prior to landfall) indicating accuracy in track, landfall and intensity

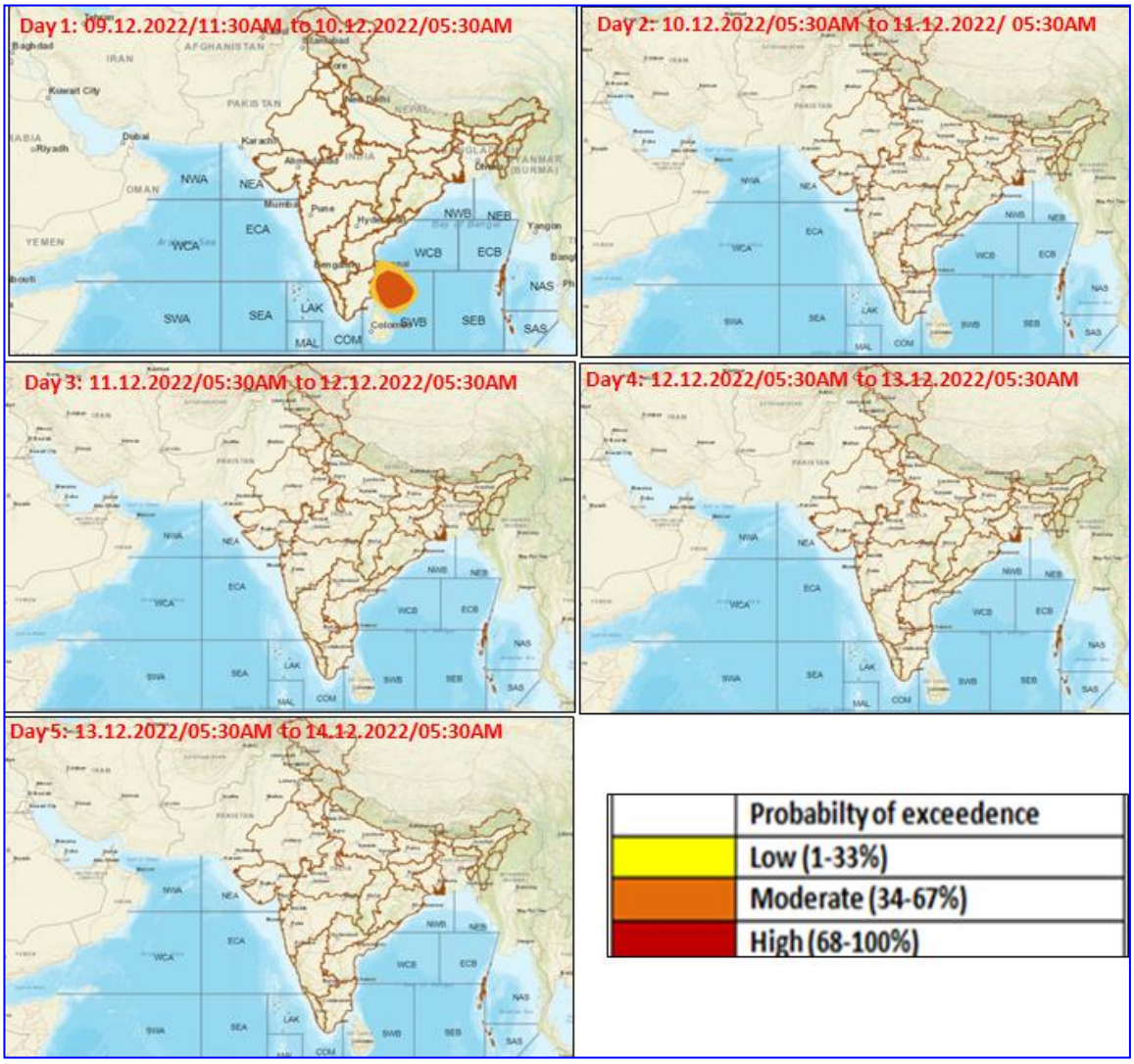


Fig.15: Probability of exceedance of maximum sustained wind speed ≥ 62 kmph (34 knots)

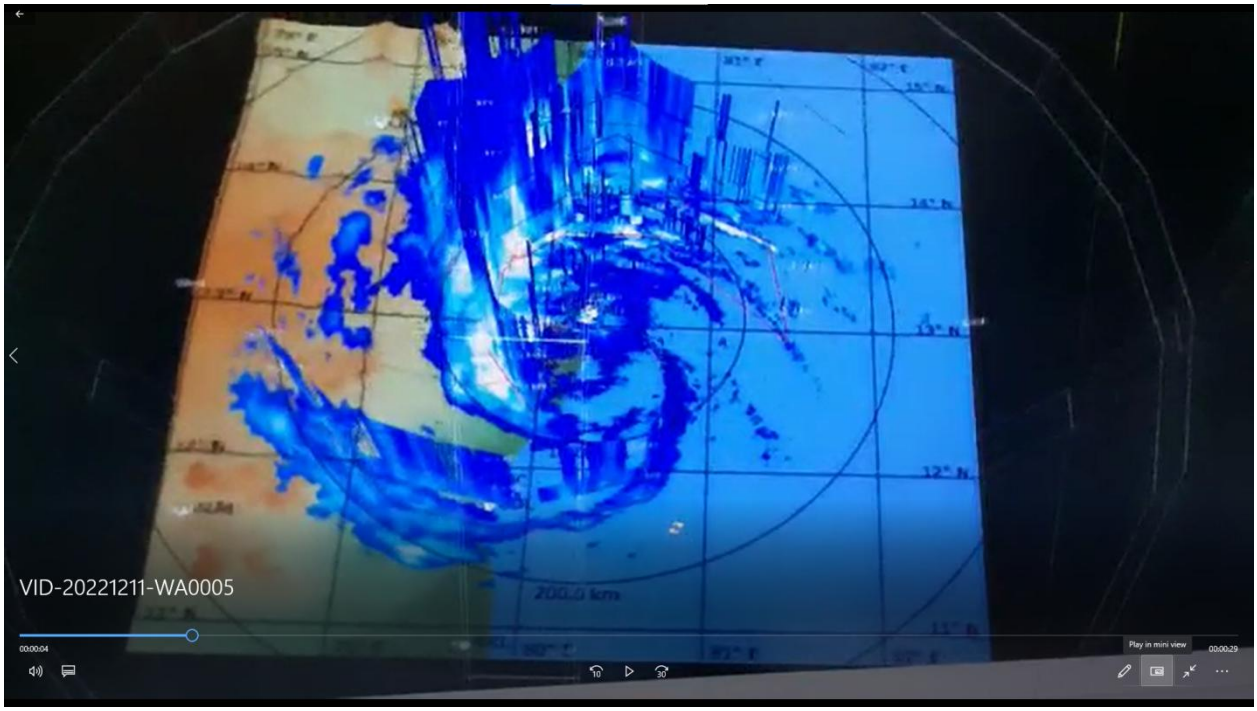


Fig.16: Realtime 3 dimensional reflectivity image of TC Mandous by Doppler Weather Radar Chennai (The movie loop is available at https://youtu.be/1S2BeFLVVfE)

Fig. 17: (a & b) Damage to standing crops in Andhra Pradesh (Deccan Chronicle, 14 Dec), (c) Collapsed roof of bus stop in Chennai (India News, 11 Dec),(d) damage photo from Sri Lanka (Business Standard, 14 Dec)