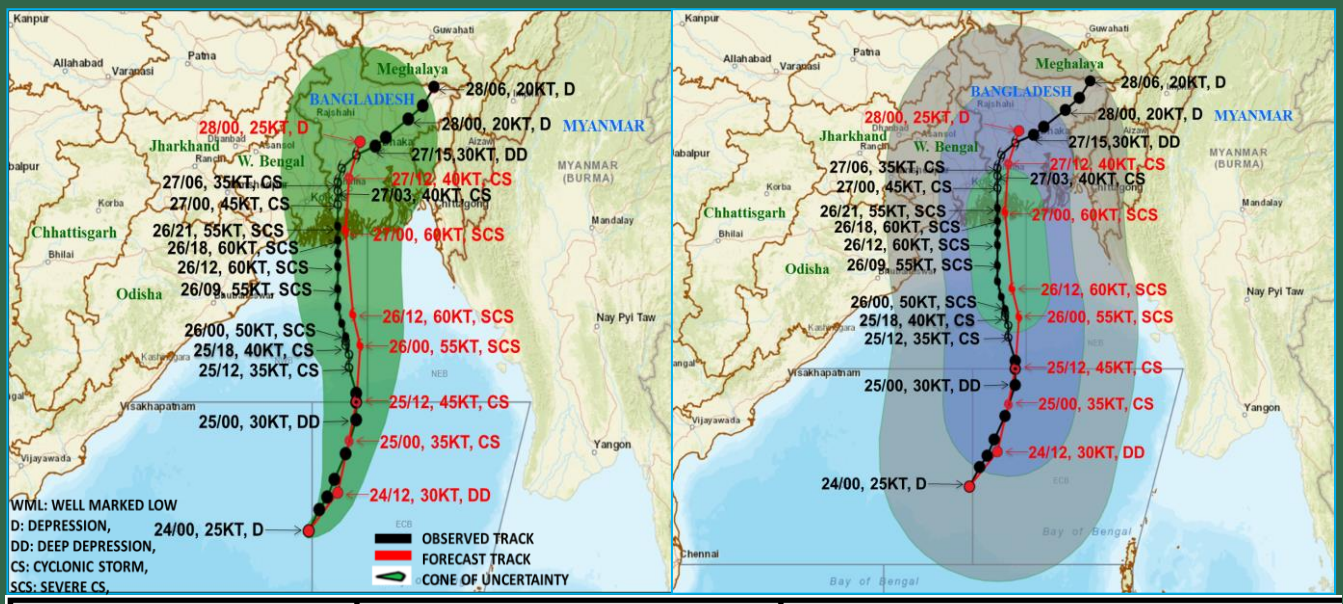
World Meteorological Organisation

Government of India
Ministry of Earth Sciences
India Meteorological Department

Annual Verification Report on Cyclonic Disturbances during 2024 over the North Indian Ocean



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

Observed and Forecast track issued at 0300 UTC of 24th May demonstrating accuracy in track and intensity forecast about 62 hours ahead of landfall

Regional Specialised Meteorological Centre, New Delhi

Annual Report on Cyclonic Disturbances during 2024 over the North Indian Ocean
Regional Specialised Meteorological Centre, New Delhi

Year 2024 witnessed the formation of 12 cyclonic disturbances (CDs) against normal of 11.2 per year based on the data during the period 1965-2023. It included 8 depressions/deep depressions (maximum sustained wind speed (MSW): 32 – 61 kmph), 2 cyclonic storms (MSW: 62-91 kmph) and 2 severe cyclonic storms (92-117 kmph). All the 4 cyclones had recurving tracks. Out of 4 cyclones, 3 were landfalling cyclones (Remal, Dana and Fengal) and the depression over northwest Madhya Pradesh moved westwards, emerged into northeast Arabian Sea, intensified into cyclonic storm Asna over northeast Arabian Sea.

Following Cyclonic Disturbances (CDs) developed over the North Indian Ocean (NIO) during 2024:

1) Severe Cyclonic Storm "REMAL" over the Bay of Bengal: 24 – 28 May
2) Depression over the Bay of Bengal: 19 – 20 July
3) Deep Depression over North Jharkhand and Neighbourhood: 02 – 06 August
4) Cyclonic Storm "ASNA" over the land: 25 August – 02 September
5) Depression over Westcentral Bay of Bengal: 31 August – 02 September
6) Deep Depression over Westcentral and Adjoining Northwest Bay of Bengal: 08 – 10 September
7) Depression over Northeast Madhya Pradesh: 11 – 13 September
8) Deep Depression over Northeast Bay of Bengal and Adjoining Bangladesh: 13 – 17 September
9) Depression over Central Arabian Sea: 13 – 15 October
10) Depression over Southwest Bay of Bengal: 15 – 16 October
11) Severe Cyclonic Storm "DANA" over Eastcentral Bay of Bengal: 22 – 26 October
12) Cyclonic Storm "FENGAL" over Southwest Bay of Bengal: 29 November – 01 December

Basin wise, out of the 4 cyclones, 3 developed over the Bay of Bengal (BoB) and 1 over the Arabian Sea (AS) against normal of 3.5 over the BoB and 1 over the AS based on the data during the period 1965-2023. Season wise, 1 CD developed over the BoB, against normal of 0.9 per year (1965-2023) during pre-monsoon season. Similarly, over the Arabian Sea there was no CD against the normal of 0.5 per year based on the data during 1965-2023. The salient features of 4 cyclones are given below.

(i) Severe Cyclonic Storm "REMAL" over the Bay of Bengal (24th – 28th May, 2024)

A low-pressure area formed over southwest and adjoining westcentral Bay of Bengal (BoB) on 23rd May. It concentrated into a depression over central BoB in the early morning (0000 UTC) of the 24th May. It intensified into a deep depression over eastcentral & adjoining BoB in the morning (0000 UTC) of 25th and into the cyclonic storm (CS) "REMAL" {pronounced as RE-MAL} over the north and adjoining eastcentral BoB in the same evening (1200 UTC) of 25th May. Continuing to move nearly northwards it intensified further into a severe cyclonic storm (SCS) over the North BoB in the early morning (0000 UTC) of 26th May. It crossed Bangladesh and adjoining West Bengal coasts between Sagar Islands and Khepupara close to southwest of Mongla between 1700

UTC of 26th May and 1830 UTC of 27th May 2024 as an SCS with wind speed of 110 to 120 kmph gusting to 135 kmph (60 gusting to 70 knots). Continuing to move northwards, it weakened into a CS over coastal Bangladesh and adjoining coastal West Bengal in the early morning (0000 UTC) of 27th May. It continued to move nearly northwards till the afternoon 1430 hours IST (0900 UTC) of 27th May and thereafter gradually recurved northeastwards. It weakened into a DD during the night (1500 UTC) of 27th May over central Bangladesh. Continuing to move further northeastwards, it weakened into a Depression over northeast Bangladesh in the early morning (0000 UTC) and into a well marked low pressure area (WML) over south Assam and neighbourhood in the evening (1200 UTC) of 28th May, 2024. The observed track of the system is presented in Fig. 1.

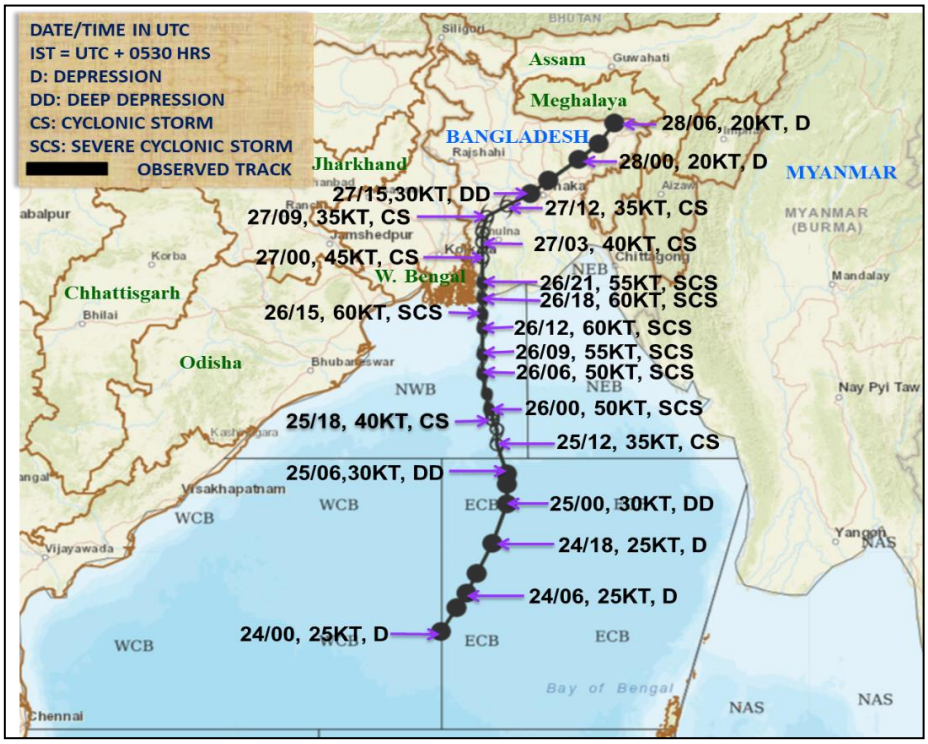


Fig. 1: Observed track of severe cyclonic storm "REMAL" over the Bay of Bengal during 24th – 28th May, 2024

Forecast Performance:

RSMC New Delhi issued first information about likely cyclogenesis (formation of depression) over BoB towards the end of the week (17th-23rd May) in the extended range outlook dated the 9th May (about 15 days ahead of formation of depression on 24th May). On 16th May, the same was reiterated with moderate confidence with likely cyclogenesis over central BoB on 16th May about 8 days before formation of depression and 11 days before landfall. Daily tropical weather outlooks from 19th May predicted moderate probability of formation during 24th–25th May, and graphical outlooks during 19th–22nd May highlighted the genesis area 5 days ahead. On 23rd May, pre-genesis track and intensity forecast was issued with genesis (formation of depression) on 24th May, with northwards movement towards the Bangladesh-West Bengal coasts.

Operational track, intensity and landfall forecast performance

- The track forecast errors for 24, 48 and 72 hrs lead period were 71, 48 and 80 km respectively against the long period average (LPA) errors of 72, 112 and 156 km respectively based on data of 2019-23 (Fig. 2a). The track forecast skills calculated against Climatology & Persistence (CLIPER) forecast for 24, 48 and 72 hrs lead period were 51, 86 and 87 km respectively against the long period average (LPA) skill of 66, 75 and 76% respectively based on data of 2019-23 (Fig. 2b). The operational track forecast errors were less than the LPA errors for all lead periods.

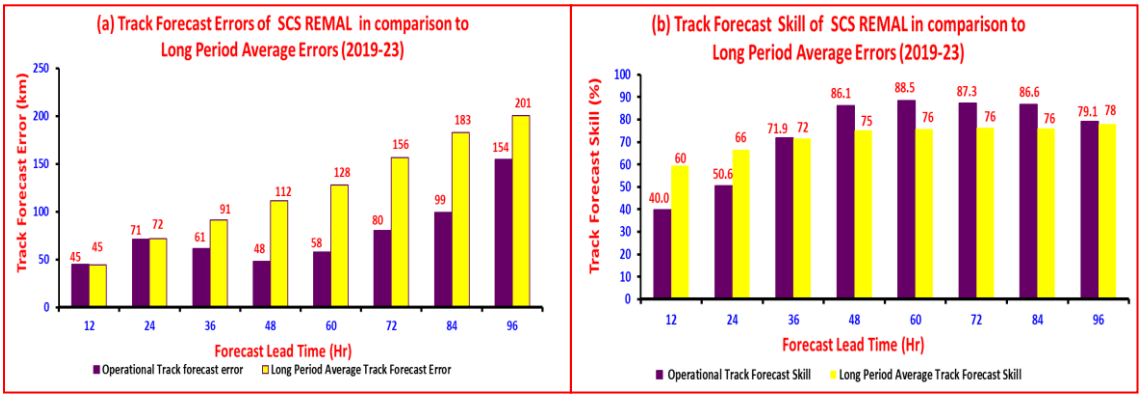


Fig.2: (a) Track forecast errors and (b) skills against Climatology & Persistence (CLIPER) compared to LPA errors & skills respectively

- The absolute errors (AE) in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 5.7, 2.2 and 6.7 knots against the LPA errors of 7.1, 10.3 and 13.8 knots based on data of 2019-23 respectively (Fig.3a). The skills in intensity forecast based on AE calculated against persistence-based forecast for 24, 48 and 72 hrs lead period were 73, 93 and 78% against the LPA skills of 57, 71 and 77% based on data of 2019-23 respectively (Fig.3b). For all lead periods, the operational intensity forecast errors were less and skills were more than the LPA.

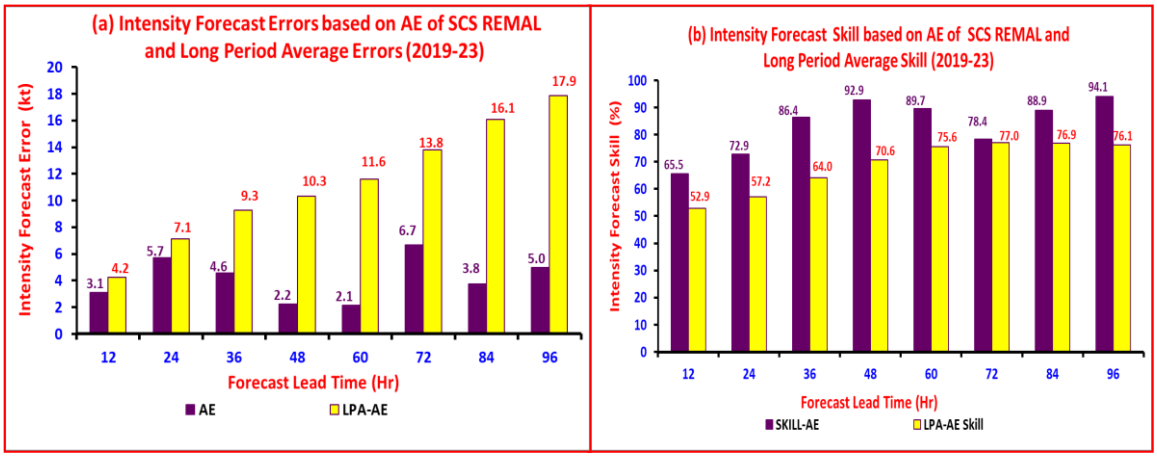


Fig.3: (a) Intensity forecast errors (AE) and (b) skills against Persistence compared to long period average (LPA of 2019-23) errors & skills respectively based on absolute error (AE)

- The landfall point forecast errors for 12, 24, 48 and 60 hrs lead periods were Zero, 20, 36 and 25 km respectively against the LPA errors of 11, 18, 42 and 56 km based on data of 2019-23 respectively (Fig.4a). Considering the average eye diameter as 50 km, there was almost zero landfall point forecast errors for all lead periods. The landfall time forecast errors for 12, 24, 48 and 60 hrs lead period were Zero, 1.0, Zero and 2.0 hours respectively against the LPA errors (2018-22) of 2, 2.8, 4.6 and 7.7 hours based on data of 2019-23 respectively (Fig.4b). For all lead periods, the landfall time errors were appreciably less than LPA errors.

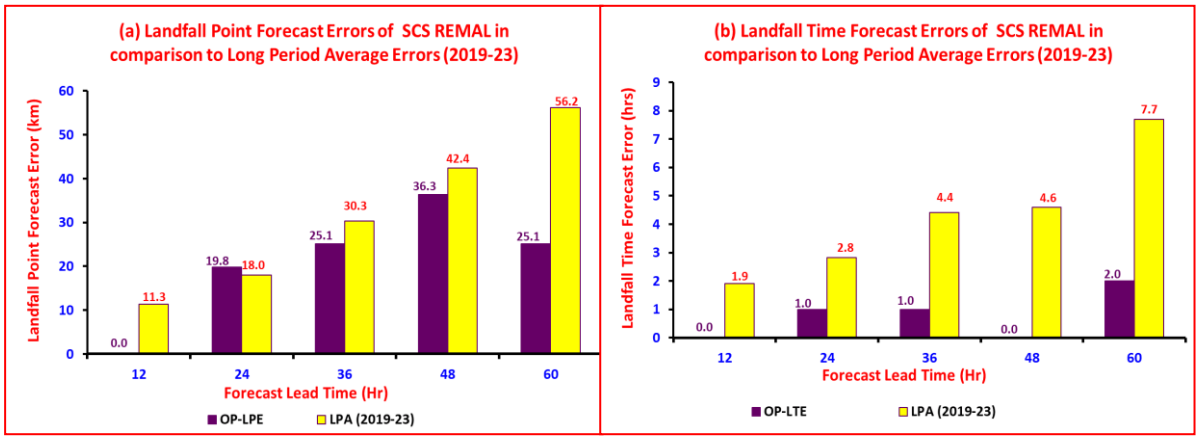


Fig.4: (a) Landfall point and (b) time errors against the long period average (LPA: 2019-2023) errors

2.2 Cyclonic Storm "ASNA" over the Arabian Sea (25th August-2nd September, 2024)

A low-pressure area formed over northwest BoB and adjoining areas of West Bengal and Bangladesh on the morning (0000 UTC) of 16th August 2024. It moved across South Bangladesh during 17th–19th August, Central Bangladesh on 20th August, and North Bangladesh during 21st –22nd August. It then moved westwards towards West Bengal and adjoining Northeast Jharkhand on 23rd August. While moving westwards, it intensified into a well-marked low-pressure area over Southeast Uttar Pradesh and adjoining northeast Madhya Pradesh on 24th August. It further intensified into a depression over Northwest Madhya Pradesh on 25th August and into a deep depression over East Rajasthan and adjoining West Madhya Pradesh later that day. The deep depression moved west-southwestwards, reaching North Gujarat by 26th August, then crossed Gujarat during 27th–29th August, and emerged into the Northeast Arabian Sea off Kachchh and adjoining Pakistan on 30th August. It intensified into Cyclonic Storm "ASNA." Over northeast Arabian Sea. Thereafter, it moved westwards and intensified slightly on 31st August. Thereafter, it moved south-southwestwards and weakened into a deep depression on 1st September and into a depression on 2nd September over northwest Arabian Sea. It further weakened into a well-marked low-pressure area in the afternoon (0600 UTC) of 2nd September and a low-pressure area over the westcentral and adjoining northwest Arabian

Sea in the morning (0000 UTC) 3rd September 2024. Observed track of the system is given in Fig. 5.

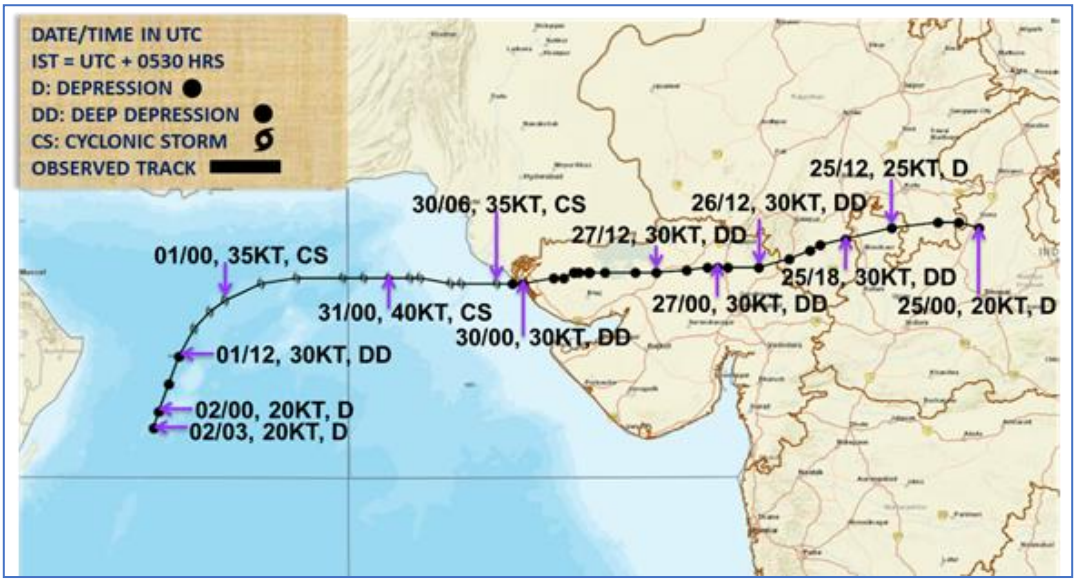


Fig. 5: Observed track of cyclonic storm "ASNA" over the Arabian Sea during 25th August– 2nd September, 2024

Forecast performance:

First information about likely of cyclogenesis (formation of Depression) with moderate confidence (34-67%) was issued in the extended range outlook issued on 15th August (about 10 days ahead of formation of depression on 25th August). The extended range outlook was further updated on 24th August. It indicated likely formation of depression over Northwest Madhya Pradesh with high confidence (68-100%) (about 1 day ahead of formation of depression) and probable emergence of system into the northeast Arabian Sea. Daily tropical weather outlook issued since 24th August indicated probability of formation of depression over land around 26th Aug.

Operational track, intensity and landfall forecast performance

The track forecast errors for 24, 48 and 72 hrs lead period were 56, 110 and 174 km respectively against the long period average (LPA) errors of 72, 112 and 156 km respectively based on data of 2019-23 (Fig.6a). The track forecast skills calculated against Climatology & Persistence (CLIPER) forecast for 24, 48 and 72 hrs lead period were 51, 53 and 70 km respectively against the long period average (LPA) skill of 66, 75 and 76% respectively based on data of 2019-23 (Fig.6b). The operational track forecast errors were less than the LPA errors for all lead periods upto 48 hours.

The absolute errors (AE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 3.2, 5.0 and 1.7 knots against the LPA errors of 7.1, 10.3 and 13.8 knots based on data of 2019-23 respectively (Fig.7a). The skills in intensity forecast based on

AEcalculated against persistence-based forecast for 24, 48 and 72 hrs lead period were 71, 71 and 50% against the LPA skills of 57, 71 and 77% based on data of 2019-23 respectively (Fig.7b). For all lead periods, the operational intensity forecast errors were less than the LPA.

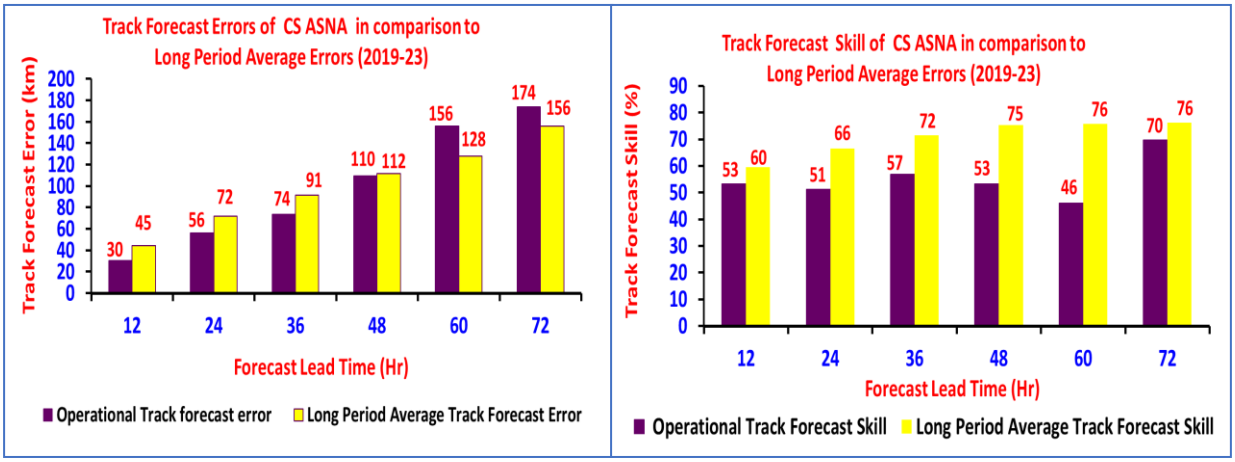


Fig. 6: (a) Track forecast error and (b) skill against Climatology & Persistence (CLIPER) forecast compared to long period average (LPA of 2019-2023) errors & skills respectively.

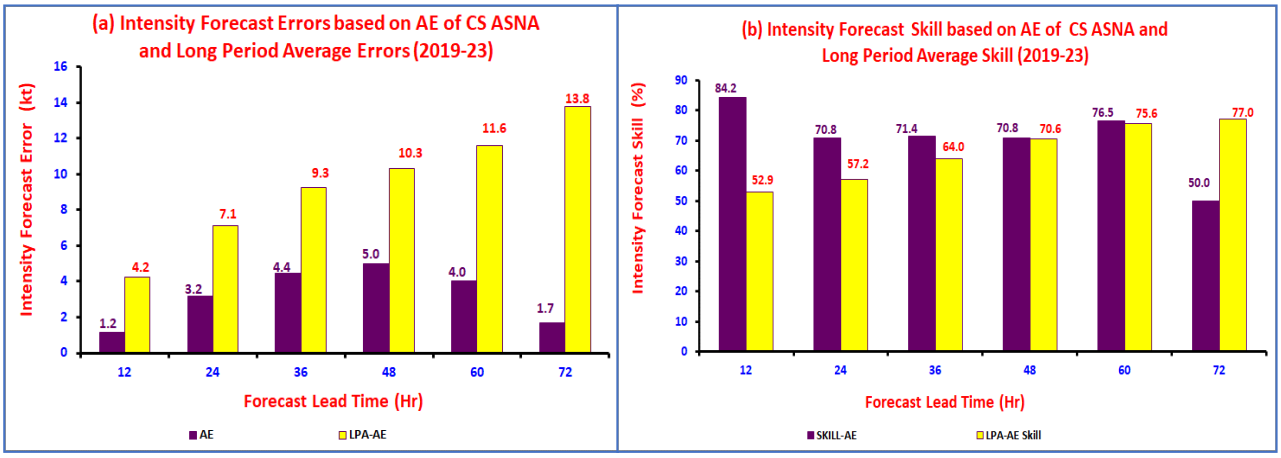


Fig. 7: (a) Absolute Error (AE) intensity forecast and (b) skill against Persistence forecast compared to long period average (LPA of 2019-23) error & skill respectively based on absolute error (AE).

2.3 Severe Cyclonic Storm "DANA" over the Bay of Bengal (22nd-26th October, 2024)

A cyclonic circulation formed over the central Andaman Sea on 19th October. It lay over North Andaman Sea on 20th October 2024. Under its influence, a low-pressure area formed over the eastcentral Bay of Bengal and adjoining north Andaman Sea in the evening (1200 UTC) of 20th October. Moving west-northwestwards, it became a well-marked low-pressure area on 21st October, a depression by the early morning of 22nd October, and a deep depression later that evening. It intensified into Cyclonic Storm "DANA" on the early morning of 23rd October, further strengthening into a severe

cyclonic storm by midnight. It made landfall near Habalikhati Nature Camp (Bhitarkanika) and Dhamara, Odisha, between 2000 and 2200 UTC on 25th October, with wind speed of 100-110 kmph gusting to 120 kmph.The landfall process began late on 24th October and lasted until the morning of 25th October. The system weakened to a cyclonic storm, then a deep depression, and eventually into a depression by the night of 25th October. It further weakened into a well-marked low-pressure area over North Odisha on the morning of 26th October 2024. Observed track of the system is given in Fig. 8.

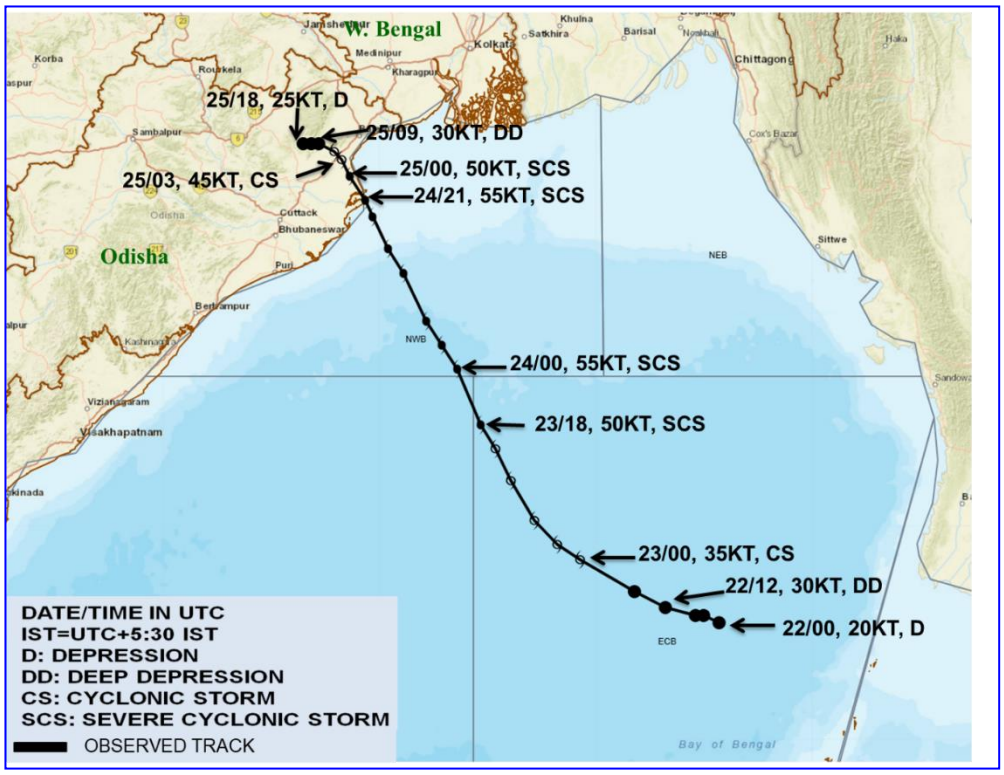


Fig. 8: Observed track of severe cyclonic storm "DANA" over eastcentral Bay of Bengal during 22-26 October, 2024

Forecast performance

First information about likely formation of an upper air cyclonic circulation over Andaman Sea around 21st October was issued in the daily report on 16th October under Tropical Cyclone Forecasting Programme carried out by IMD since 2008 during October to December as an initiative to improve forecast through enhanced observations & model guidance (about 3 days ahead of the formation of upper air cyclonic circulation over central Andaman Sea on 19th October). First information about likelihood of cyclogenesis (formation of Depression) with High confidence (67-100%) was issued in the extended range outlook issued on 17th October (about 5 days ahead of formation of depression on 22nd October).

Track, intensity and landfall forecast performance

The track forecast errors for 24, 48 and 72 hrs lead period were 32, 24 and 29 km against the long period average errors of 72, 112 and 156 km respectively based on the data of 2019-23 (Fig.9a). The track forecast skills calculated against Climatology & Persistence (CLIPER) forecast for 24, 48 and 72 hrs lead period were 84, 95 and 96 % respectively

against the long period average skills of 66, 75 and 76% respectively based on the data of 2019-23 (Fig.9b). For all lead periods, the operational track forecast errors were markedly below the long period average errors.

The absolute errors (AE) in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 2.7, 5.0 and 3.8 knots against the long period average errors of 7.1, 10.3 and 13.8 knots based on the data of 2019-23 respectively (Fig.10 a). The skills in intensity forecast based on AE calculated against the persistence-based forecasts for 24, 48 and 72 hours lead period were 81, 81 and 90 % against the long period average skills of 57, 71 and 77% based on data of 2019-23 respectively (Fig.10 b). For all lead periods, the operational intensity forecast errors were less and the skills were more than the long period average.

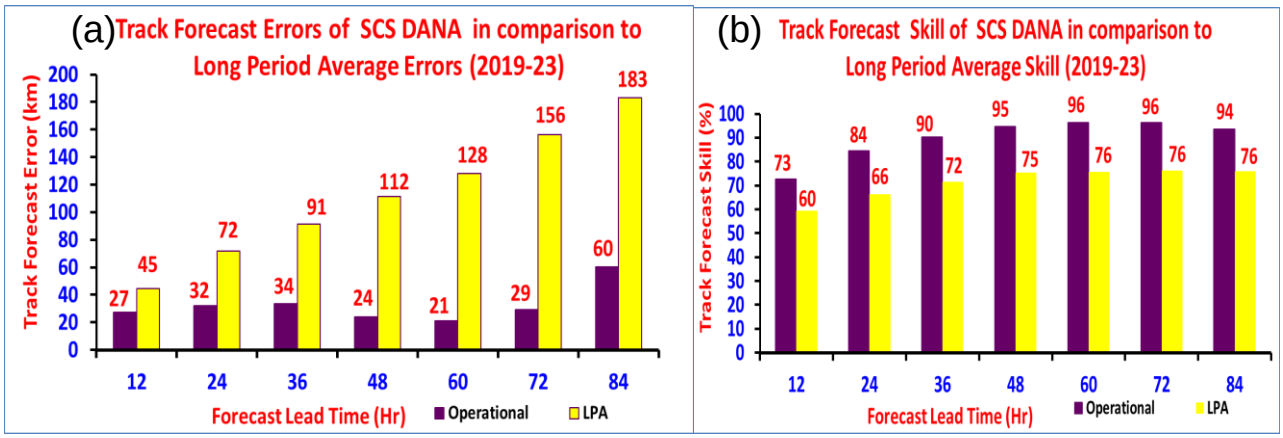


Fig.9: (a) Track forecast errors and (b) skills against Climatology & Persistence (CLIPER) compared to long period average (LPA) errors & skills respectively based on 2019-2023

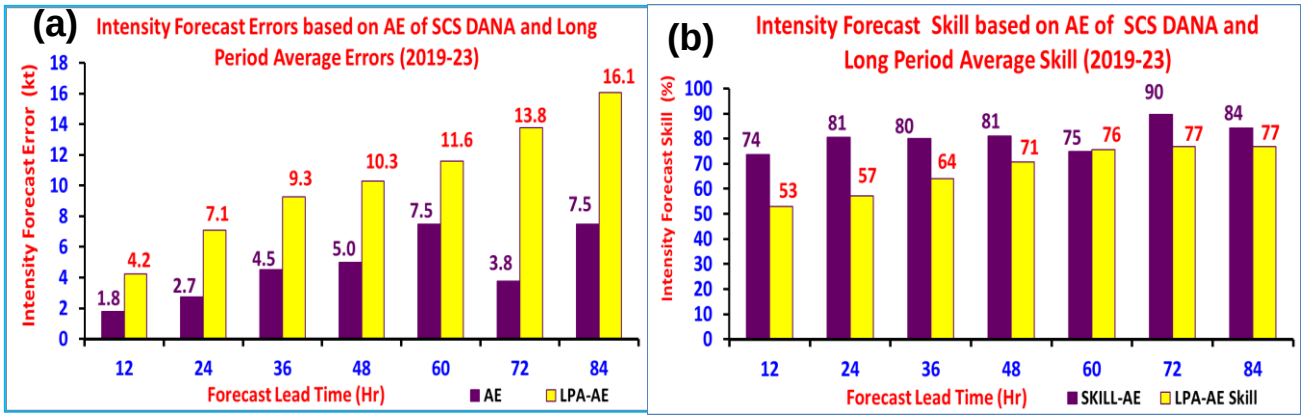


Fig.10: (a) Intensity forecast errors (AE) and (b) skills against Persistence compared to long period average (LPA) errors & skills respectively based on absolute error (AE)

The landfall points forecast errors for 24, 48 and 72 hrs lead period were 4, 2 and 2 km respectively against the long period average errors of 18, 42 and 73 km based on data of 2019 - 23 (Fig.11a). The landfall time forecast errors for 24, 48 and 72 hrs lead period were 2.5, 0.5 and 0.5 hours respectively against the long period average error of 2.8, 4.6 and 9.5 hours respectively based on the data of 2019-23 (Fig.11b). The operational landfall point & time forecast errors were markedly less than the LPA errors for all lead periods. There was almost zero error in landfall point prediction for all lead periods upto

90 hours. The landfall intensity forecast errors were also almost zero even upto 90 hrs lead period.

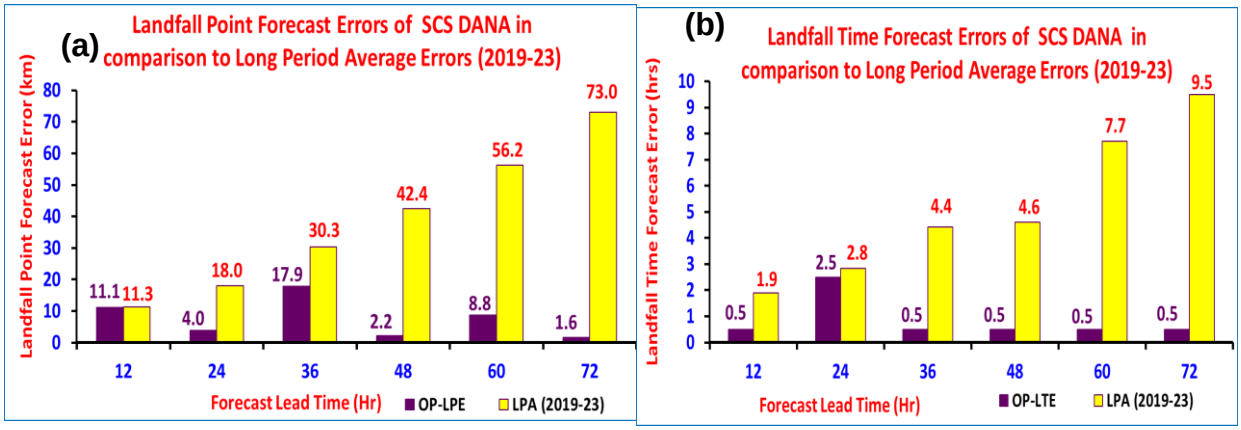


Fig. 11: (a) Landfall point and (b) time errors against the long period average (LPA) errors based on 2019-2023

2.4 Cyclonic Storm FENGAL over Bay of Bengal (25-31 November)

Cyclonic storm Fengal developed from a low pressure area that formed over East Equatorial Indian Ocean (EEIO) and adjoining Southeast BoB in the morning (0300 UTC) of 23rd November. It moved west-northwestwards, and became a well-marked low pressure area over southeast BoB and adjoining EEIO in the morning (0300 UTC), of 24th November. Further moving west-northwestwards, it intensified into a depression over central parts of south BoB and adjoining EEIO in the morning (0300 UTC) of 25th November, into a deep depression over Southwest BoB in the morning (0300 UTC) of 26th November and into the cyclonic storm "FENGAL" [pronounced as FEINJAL] over Southwest BoB in the afternoon (0900 UTC) of 29th November. Thereafter, it moved initially westwards, then west-southwestwards and crossed North Tamil Nadu & Puducherry coasts close to Puducherry, between 1700 and 1800 UTC of 30th November as a cyclonic storm with a wind speed of 70-80 kmph gusting to 90 kmph. Thereafter, it remained practically stationary over the same region and weakened into a deep depression in the forenoon (0600 UTC) and into a depression over the same region in the evening (1200 UTC) of 1st December. It then moved nearly westwards and weakened into a Well-Marked Low Pressure Area over North Interior Tamil Nadu in the early morning (0000 UTC) of 2nd December. Observed track of the system is presented in Fig. 12.

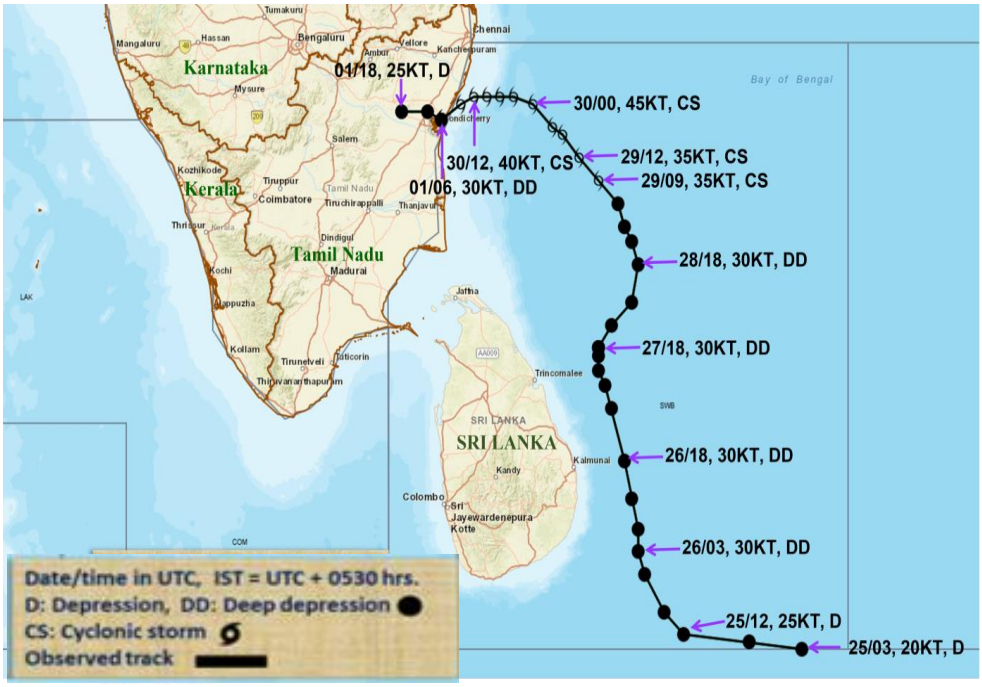


Fig. 12: Observed track of severe cyclonic storm "Fengal" over Bay of Bengal during 25-31 August, 2024

Forecast performance

The genesis of cyclone Fengal was first predicted in the extended range outlook issued on 14th November 2024. It was again reiterated on 21st November with high probability. Genesis occurred on 25th Nov. 2024. It was predicted to cross coast close to Puducherry since evening of 27th November (78 hrs in advance of landfall)

Track, intensity and landfall forecast performance

The track forecast errors for 24, 48, and 72 hours lead periods were 45, 112, and 128 km, respectively, against the LPA errors of 72, 112, and 156 km (Fig.13). The operational track forecast errors consistently outperformed the LPA benchmarks, underscoring the improved track prediction capabilities overall lead periods.

The absolute errors in intensity forecast for 24, 48, and 72 hours lead periods were 4.2, 7.3, and 5.5 knots, respectively, against the LPA errors of 7.1, 10.3, and 13.8 knots (Fig.14). The operational intensity forecast errors were less than the long-period average errors for all lead periods.

The landfall point forecast errors for 24, 36, and 48 hours lead periods were 5.5, 22.3, and 15.3 km, respectively, against the long-period average (LPA) errors of 18.0, 30.3, and 42.4 km (Fig.15a). The operational landfall point forecast errors were significantly below the LPA errors for all lead periods, showcasing an improved accuracy in predicting the landfall location.

The landfall time forecast errors for 24, 48, and 60 hours lead periods were 7.0, 6.0, and 13.0 hours, respectively, compared to LPA errors of 2.8, 4.4 and 4.6 hours (Fig. 15b). The operational errors were more than LPA errors for all lead periods because the system had a recurving track and thus the landfall time could not be predicted accurately.

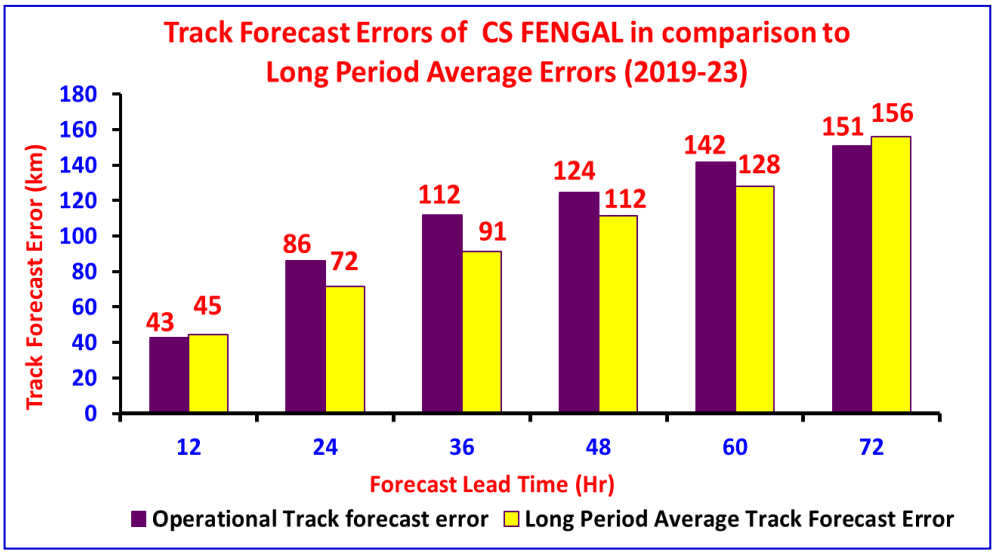


Fig. 13: Track forecast errors compared to long period average (LPA) errors & skills respectively based on 2019-2023

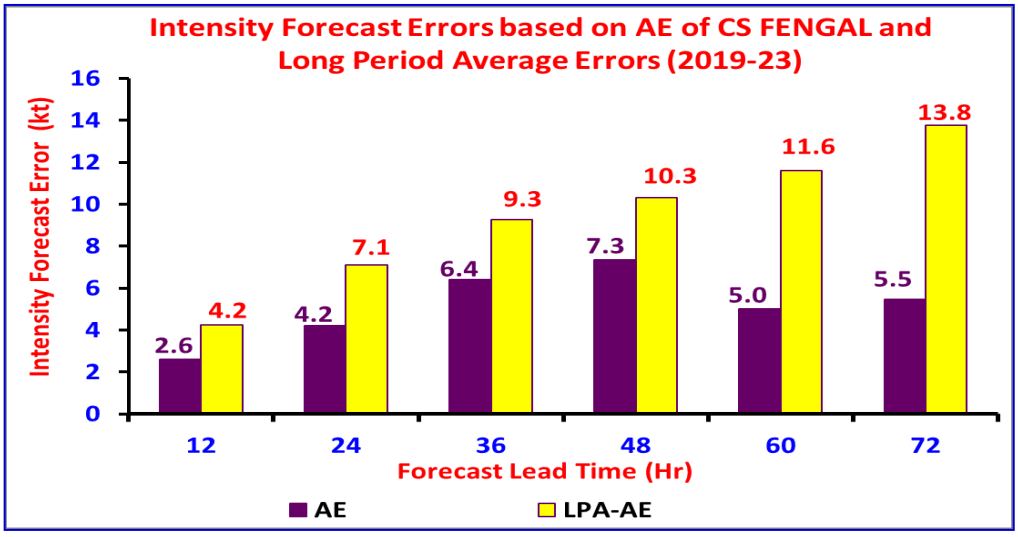


Fig.14: Intensity forecast errors (AE) compared to long period average (LPA) errors & skills respectively based on absolute error (AE).

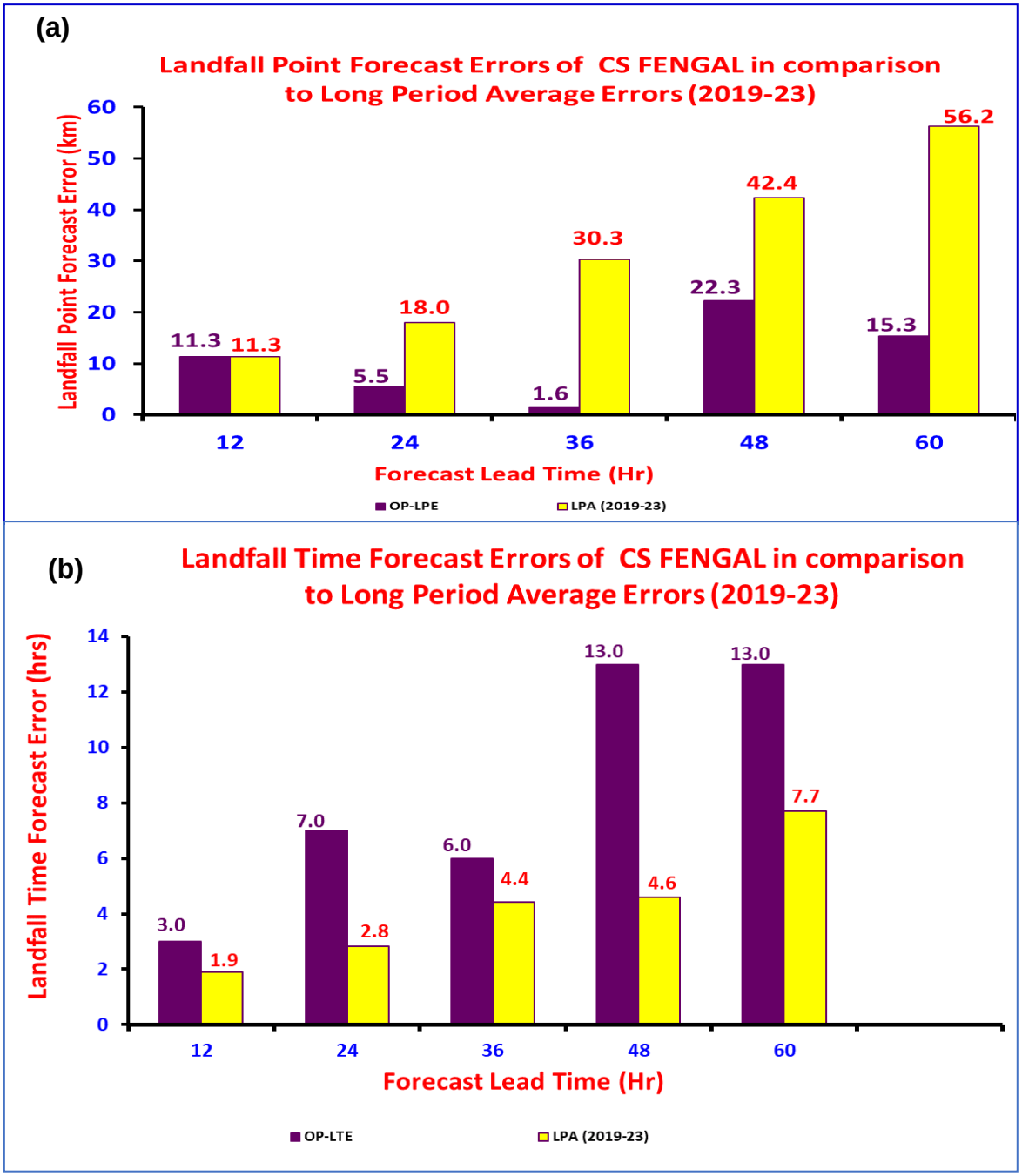


Fig. 15: (a) Landfall point and (b) time errors against the long period average (LPA) errors based on 2019-2023

3.1 Annual Performance of cyclone landfall, track and intensity forecast:

The annual average track forecast errors in 2024 have been 66 km, 84 km and 116 km, for 24, 48 and 72 hrs respectively against the past five-years average error of 72, 112 and 156 km based on data of 2019-2023. For all lead periods, the errors have been lesser during this year as compared to long period average (LPA) (2019-23). The track forecast skills compared to climatology and persistence forecast have been 64%, 79% and 83% respectively for the 24, 48 and 72 hrs lead period which was also less than long period average of 2019-2023 (66%, 75% & 73% respectively). The annual average track forecast errors and skill during 2024 are presented in Fig. 16(a-b).

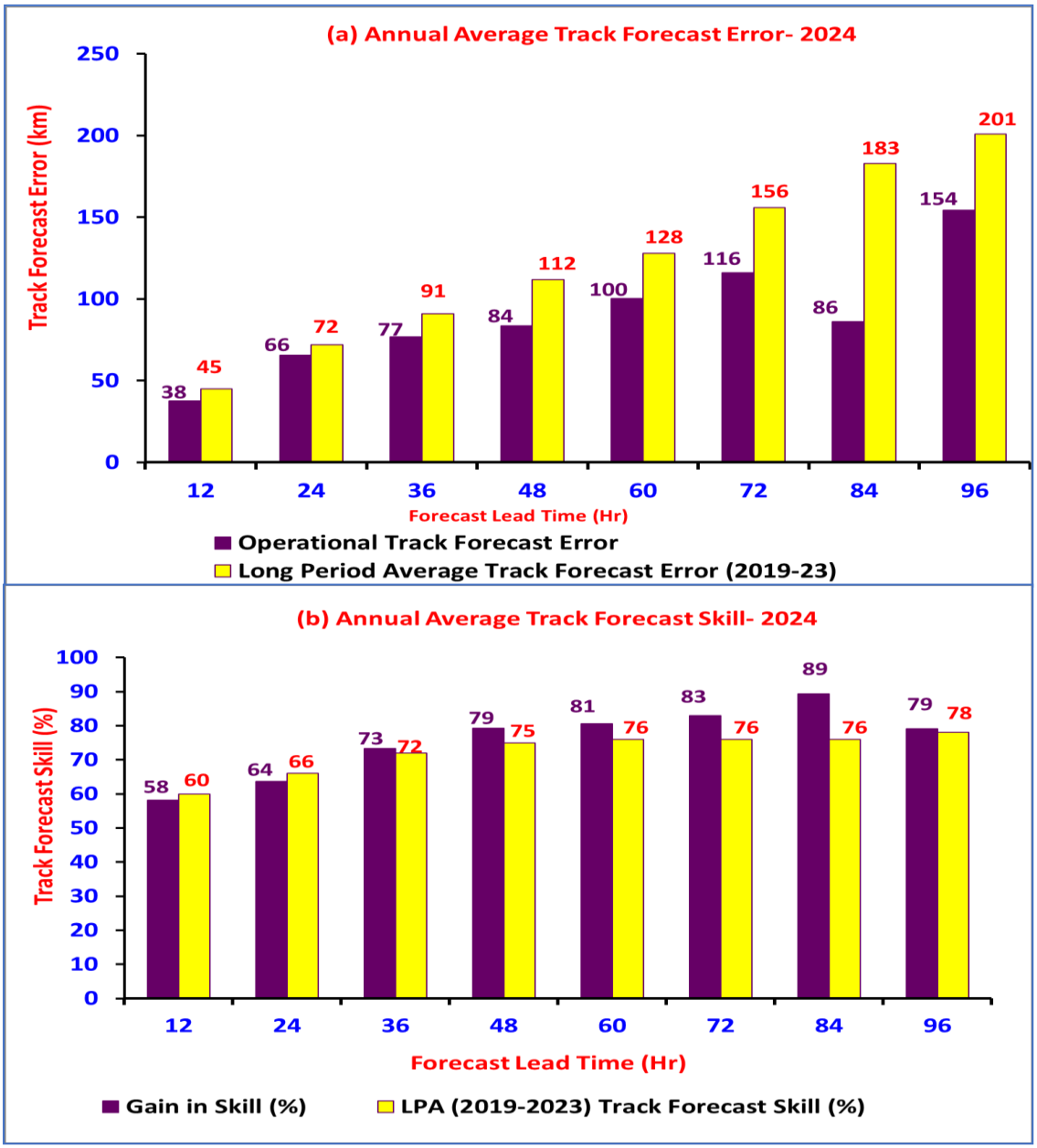
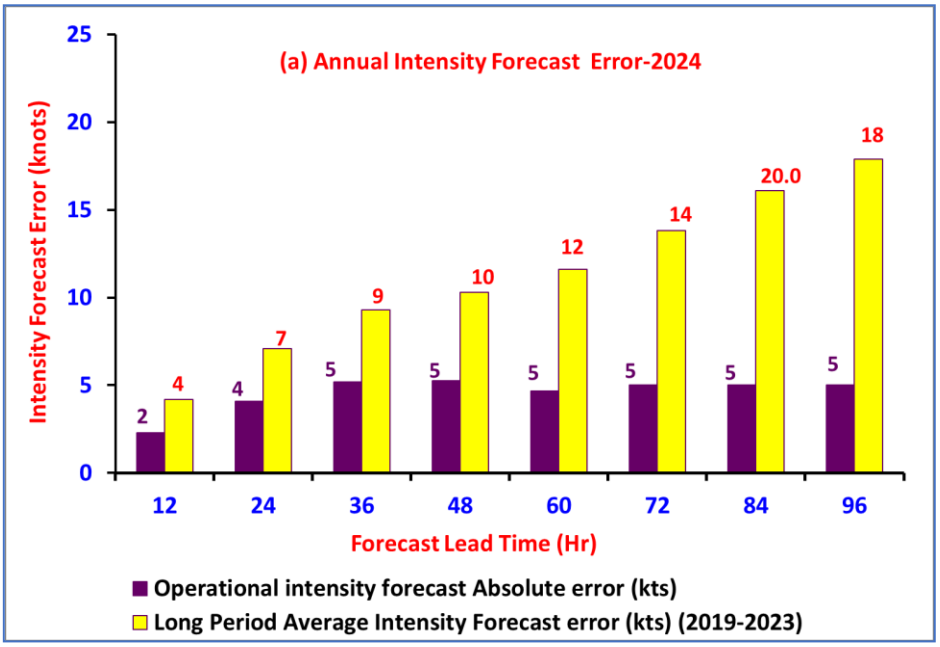


Fig.16: Annual average track forecast (a) error (km) (b) skills (%) during 2024 as compared to LPA of that during 2019-2023.

The annual average absolute error (AE) in intensity forecast error (Fig.3.1.2 a) has been 4, 5 and 5 knots respectively for 24, 48 and 72 hrs lead period of forecast against the past five-year average of 7, 10 and 14 knots. The annual average root mean square error (RMSE) in intensity forecast error (Fig.3.1.2 b) has been 5 knots, 7 knots and 7 knots respectively for 24, 48 and 72 hrs lead period of forecast against the past five year average of 9, 13 and 17 knots. The annual average intensity forecast error based on AE and RMSE during 2024 are presented in Fig. 17 (a-b).



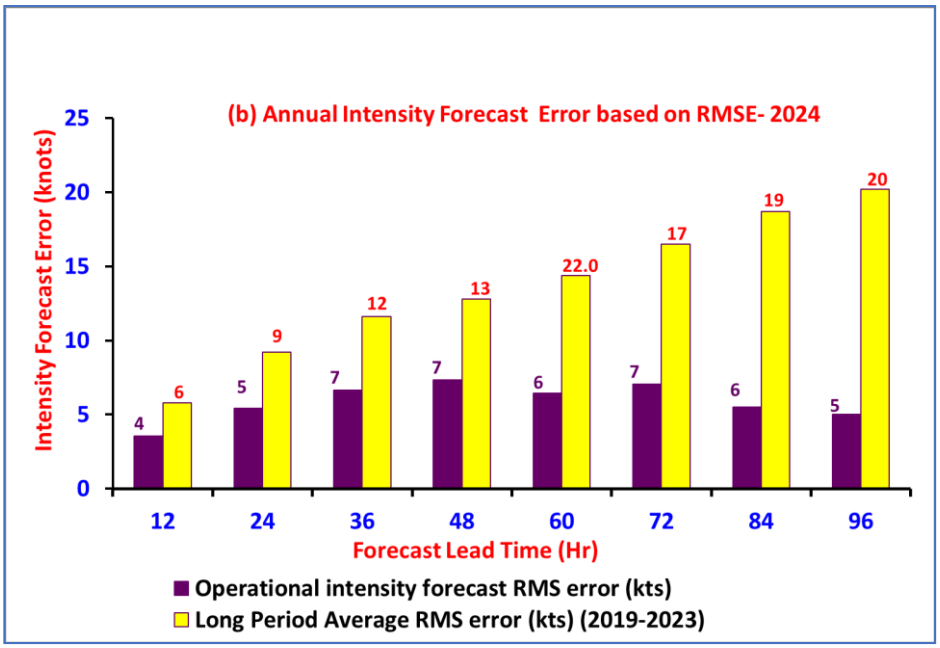


Fig.17 Annual average intensity forecast error (km) (a) based on AE (b) based on RSME during 2024 as compared to LPA of that during 2019-2023

The annual average landfall point forecast errors for the year 2024 have been 14 km, 24 km and 2 km for 24, 48 and 72 hrs lead period against the past five years average errors of 18 km, 42 km and 73 km during 2019-2023. The landfall time forecast errors have been 3.1, 3.6 and 0.5 hrs for 24, 48 and 72 hrs lead period during 2024 against the average of past five years of 2.8, 4.6 and 9.5 hrs during 2019-2023. Annual average landfall forecast errors for the year 2024 and the landfall time forecast errors during 2024 against the average of past five years during 2019-2023 are presented in **Fig. 18(a-b)**.

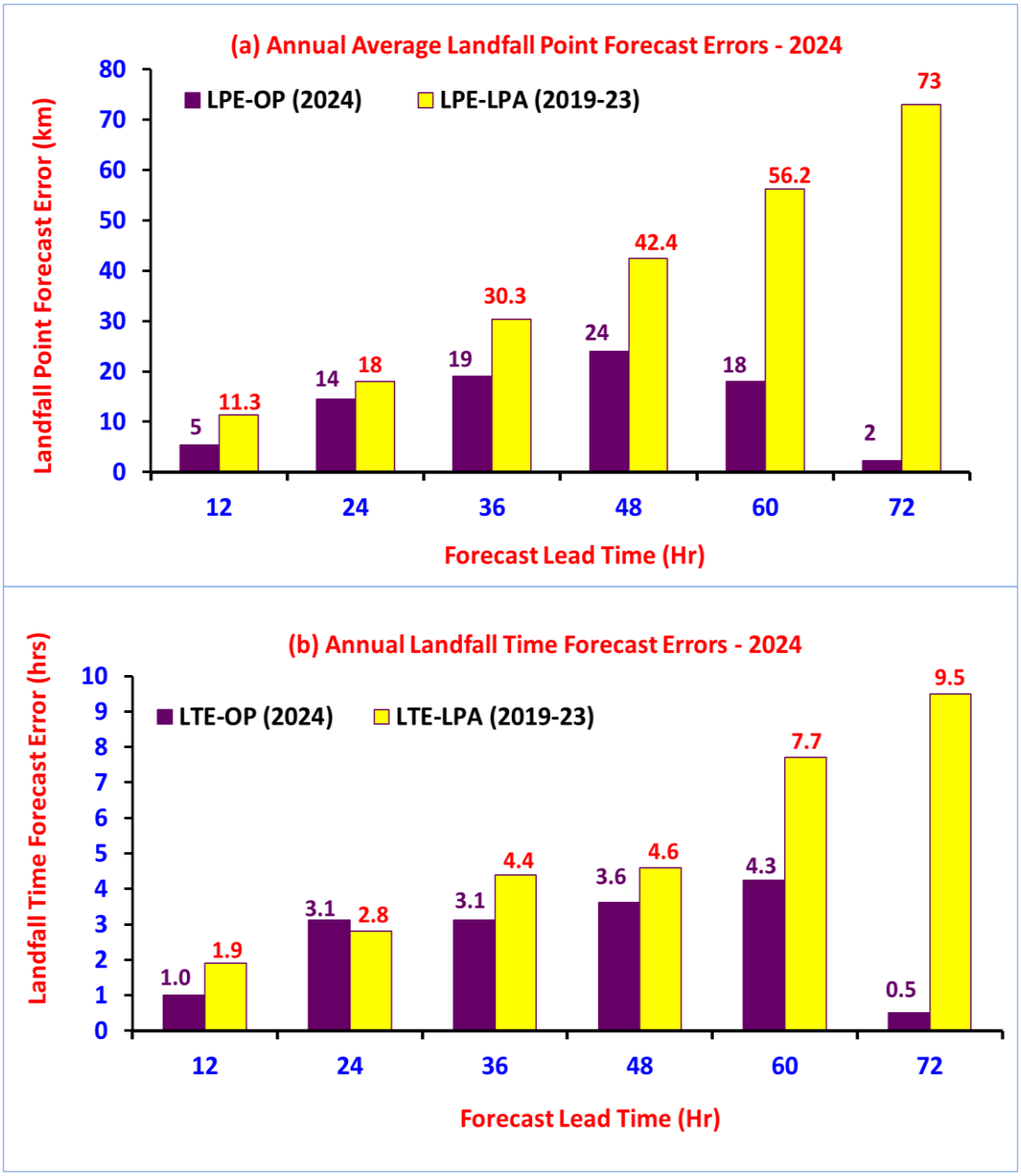


Fig.18. Annual average (a) landfall points forecast error (km) and (b) landfall time forecast errors as compared to long period average errors during 2019-2023

3.2 Comparative analysis of forecast accuracy in recent five years (2020-24) as compared to previous five years (2019-23)

The comparative analysis of average track forecast error and skill during 2020-24 and 2015-19 is presented in Fig.19. The average track forecast errors during 2020-24 were 72 km, 111 km & 154 km against 81 km, 126 km & 171 km during 2015-19for 24, 48 and 72 hrs lead period respectively. The 24, 48 and 72 hr average track forecast skills during 2020-24 were 65%, 74% and 77% against 61%, 73% and 74% respectively during 2015-19.

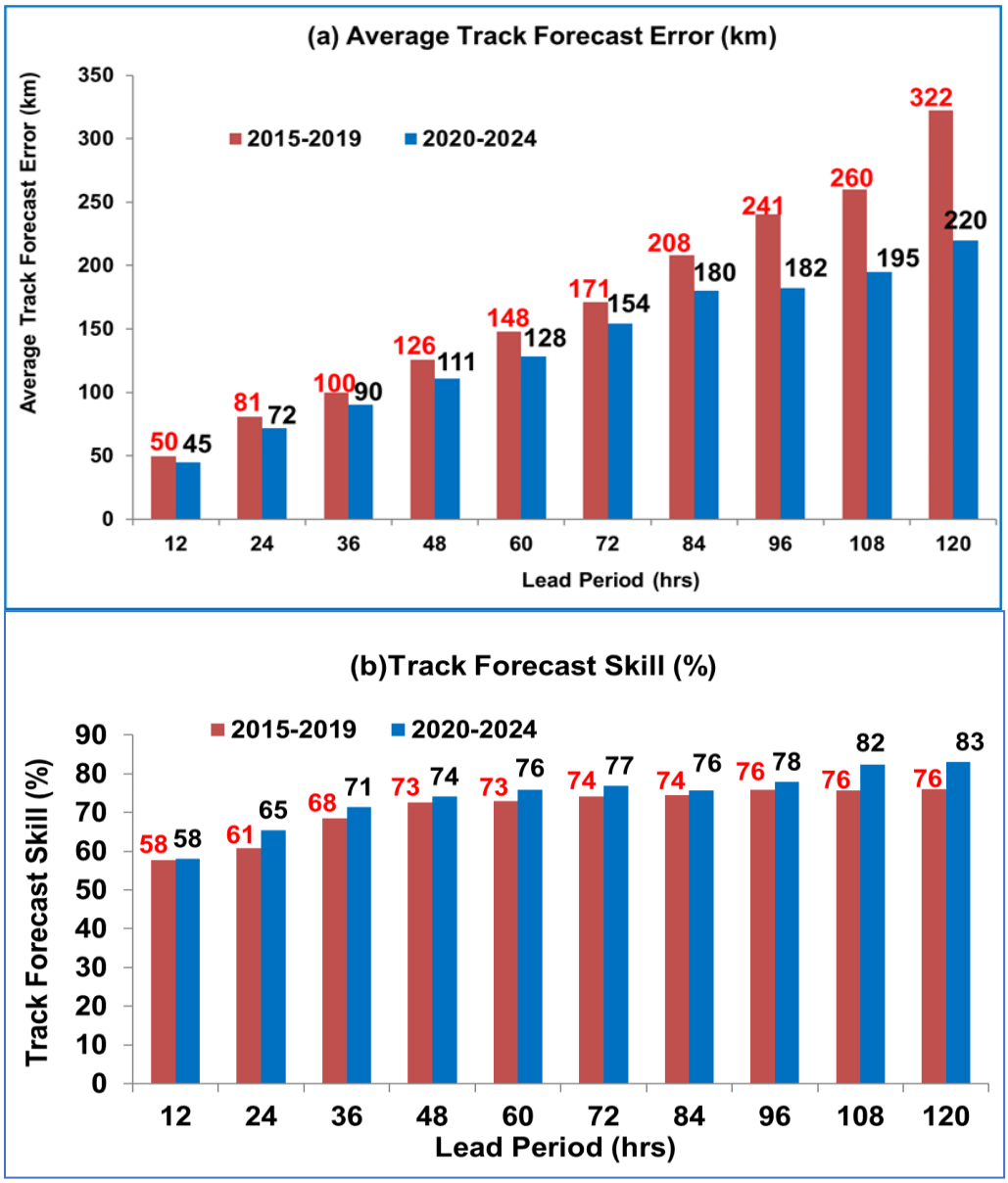


Fig.19: Comparative Average track forecast (a) error (km) (b) skill (%) during 2020-2024 Vis-à-Vis 2015-19

The comparative analysis of average intensity forecast error and skill based on AE and RMSE during 2020-24 and 2015-19 are presented in Fig.20 (a&b). The average intensity forecast error based on AE for 24hrs, 48hrs and 72hrs are 5.9 knots, 8.3 knots and 9.8 knots during 2020-24 against 8.9 knots, 13.0 knots and 15.4 knots during 2015-19. Based on RMSE the intensity forecast errors were 7.9 knots, 11.0 knots and 19.2 knots during 2020-24 against 11.5 knots, 16.7 knots, and 19.2 knots during 2015-19. It can be seen that there has been marginal improvement in intensity forecast during recent five years (2020-24) as compared to previous five years (2015-19).

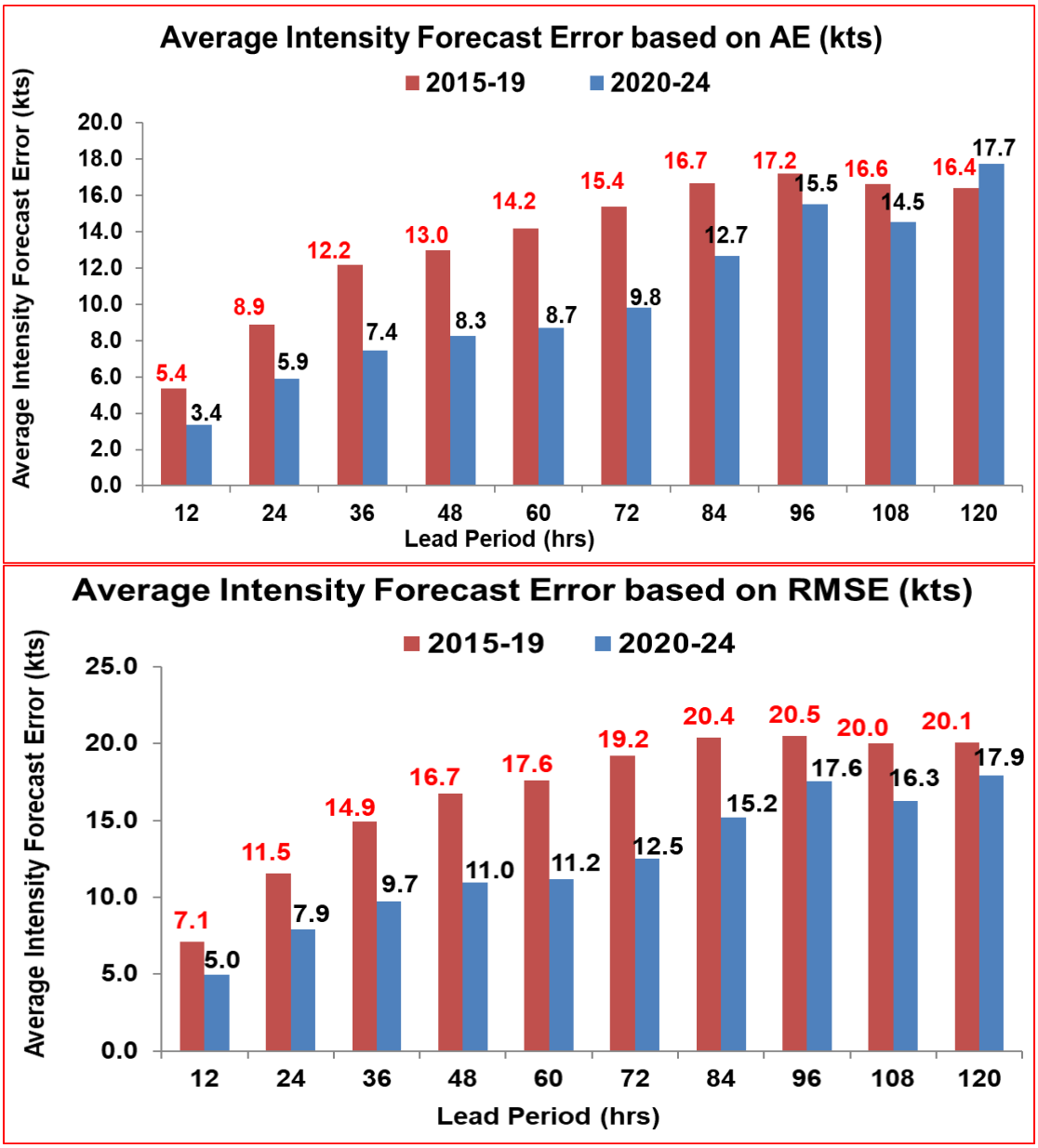


Fig.20: Comparative Average Intensity forecast errors (kts) based on (a) absolute error and (b) root mean square errors during 2020-2024 vis-à-vis 2015-19

Comparative analysis of landfall point error (LPE) and landfall time error (LTE) during 2020-24 vis-à-vis 2015-19 is presented in Fig. 21 (a & b). The LPE for 24, 48 and 72 hrs lead period during 2020-24 were 16.2 km, 39.3 km and 69.5 km against 44.7 km, 69.4 km and 109.3 km respectively during 2015-19. The LTEs for 24, 48 and 72 hrs lead period during 2020-24 were 2.9hrs, 4.2hrs &7.5hrs against 3.0 hrs, 5.4hrs & 8.6hrs respectively during 2015-19.

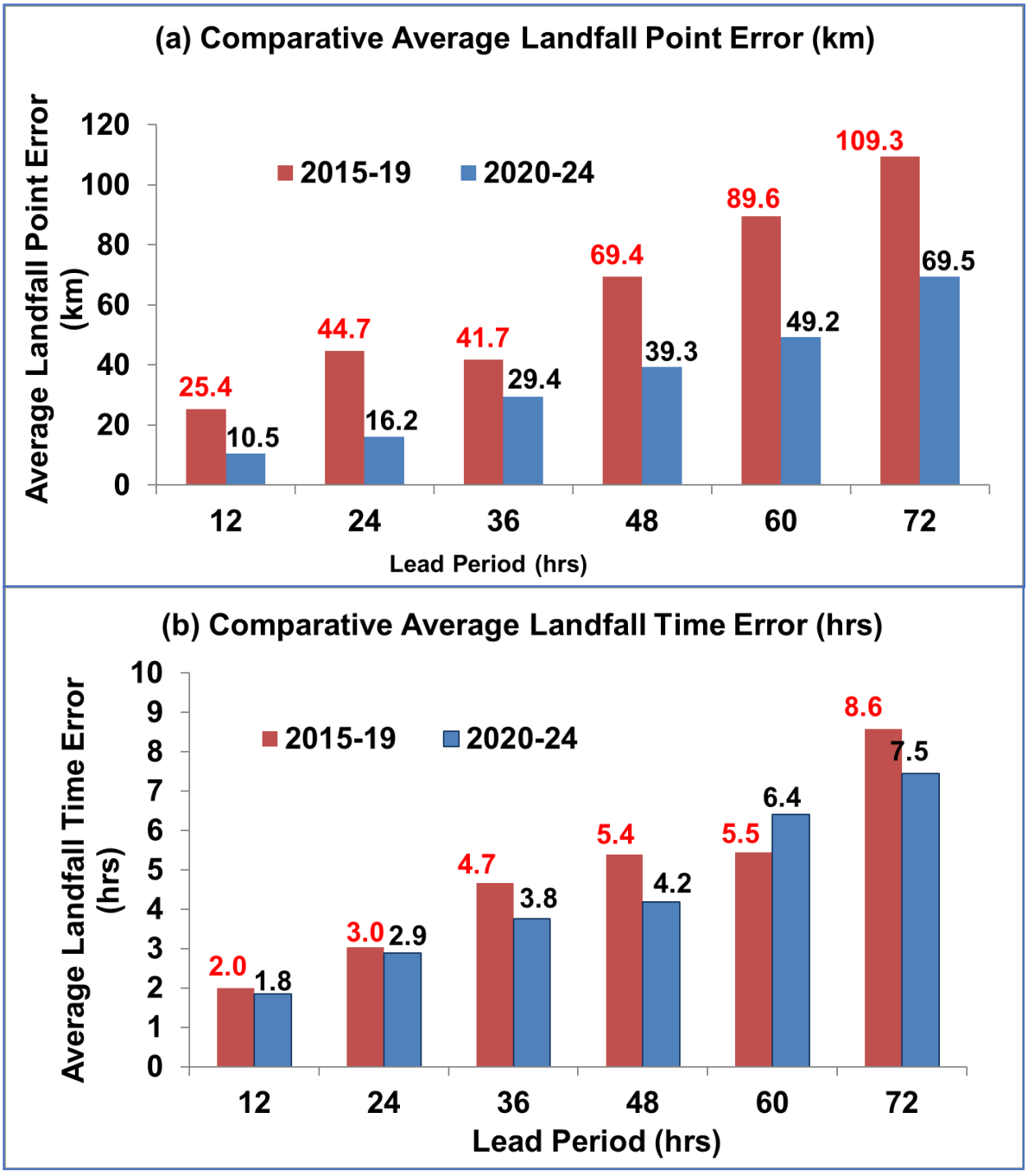


Fig.21: Comparative average landfall (a) points and (b) time forecast errors during 2020-2024 vis-à-Vis 2015-19

3.3 Five Year Moving Average errors and skill over north Indian Ocean

Five year moving average track forecast errors and corresponding skills for different lead periods upto 120 hours are presented in Fig. 22, indicating consistent decrease in track forecast errors over the years since 2003. Five year mean average has been calculated and presented here, as the annual frequency of cyclones is very less over the NIO.

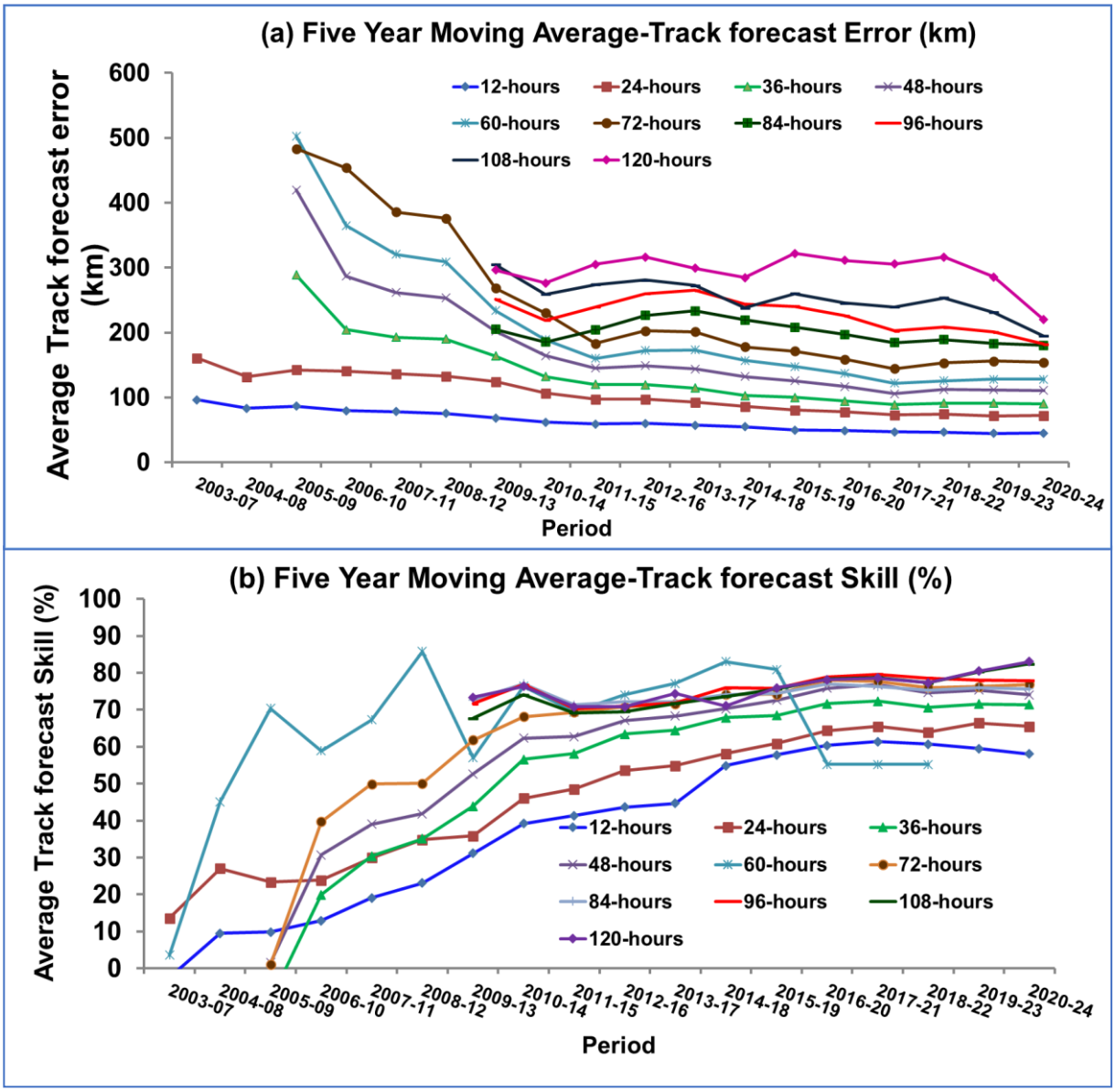


Fig. 22: Five Year Moving Average (a) Errors in Track Forecast (km) and (b) skill of RSMC, New Delhi over north Indian Ocean

Five year moving average intensity forecast errors and corresponding skills for different lead periods upto 120 hours are presented in Fig. 23 indicating consistent decrease in intensity forecast errors since 2003

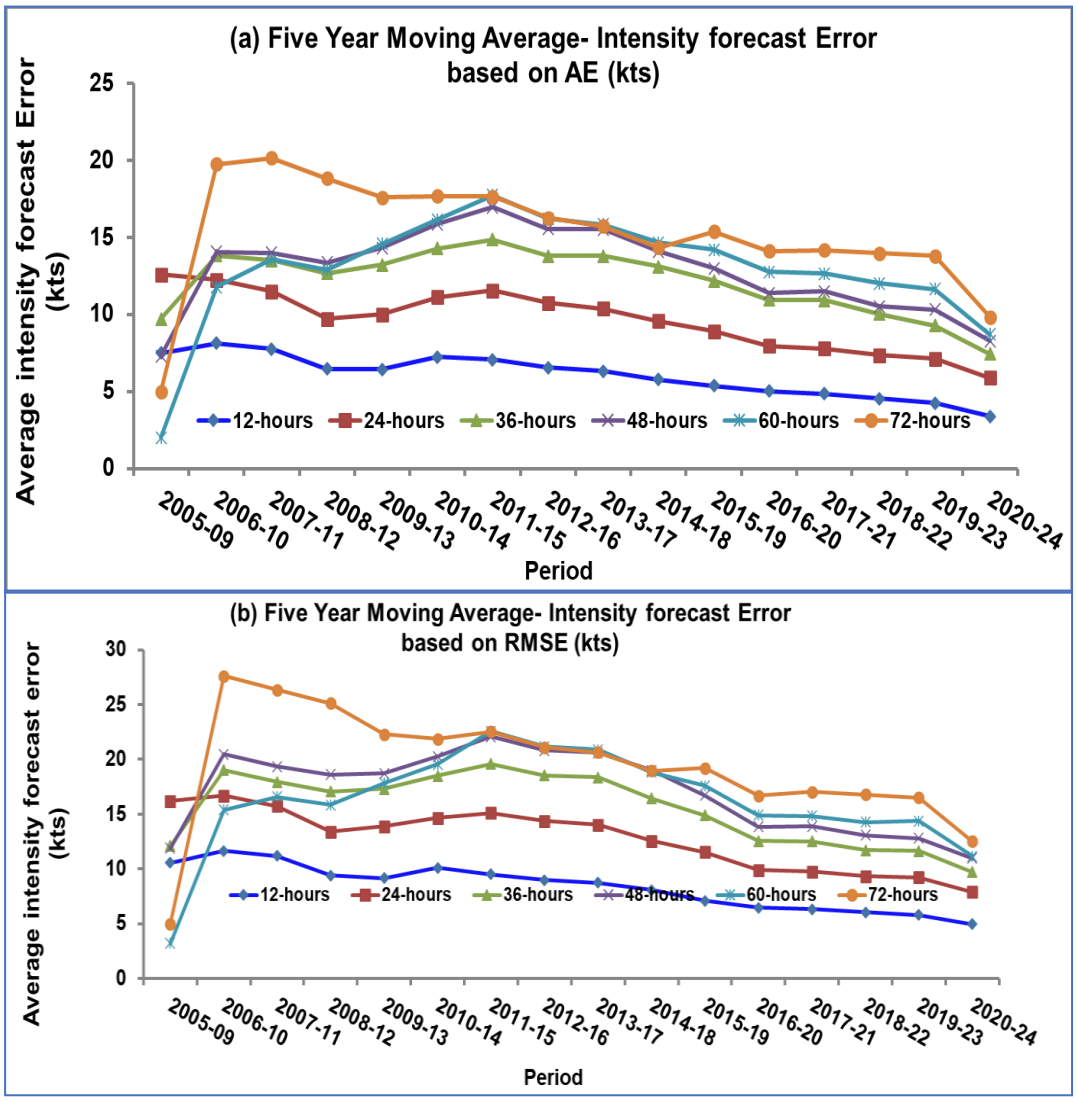


Fig. 23 Five Year Moving Average Intensity Forecast skill based on (a) AE and (b) RMSE of RSMC, New Delhi over North Indian Ocean

Five year moving average landfall point and time forecast errors for different lead periods upto 120 hours are presented in Fig. 24 indicating consistent decrease in intensity forecast errors since 2003

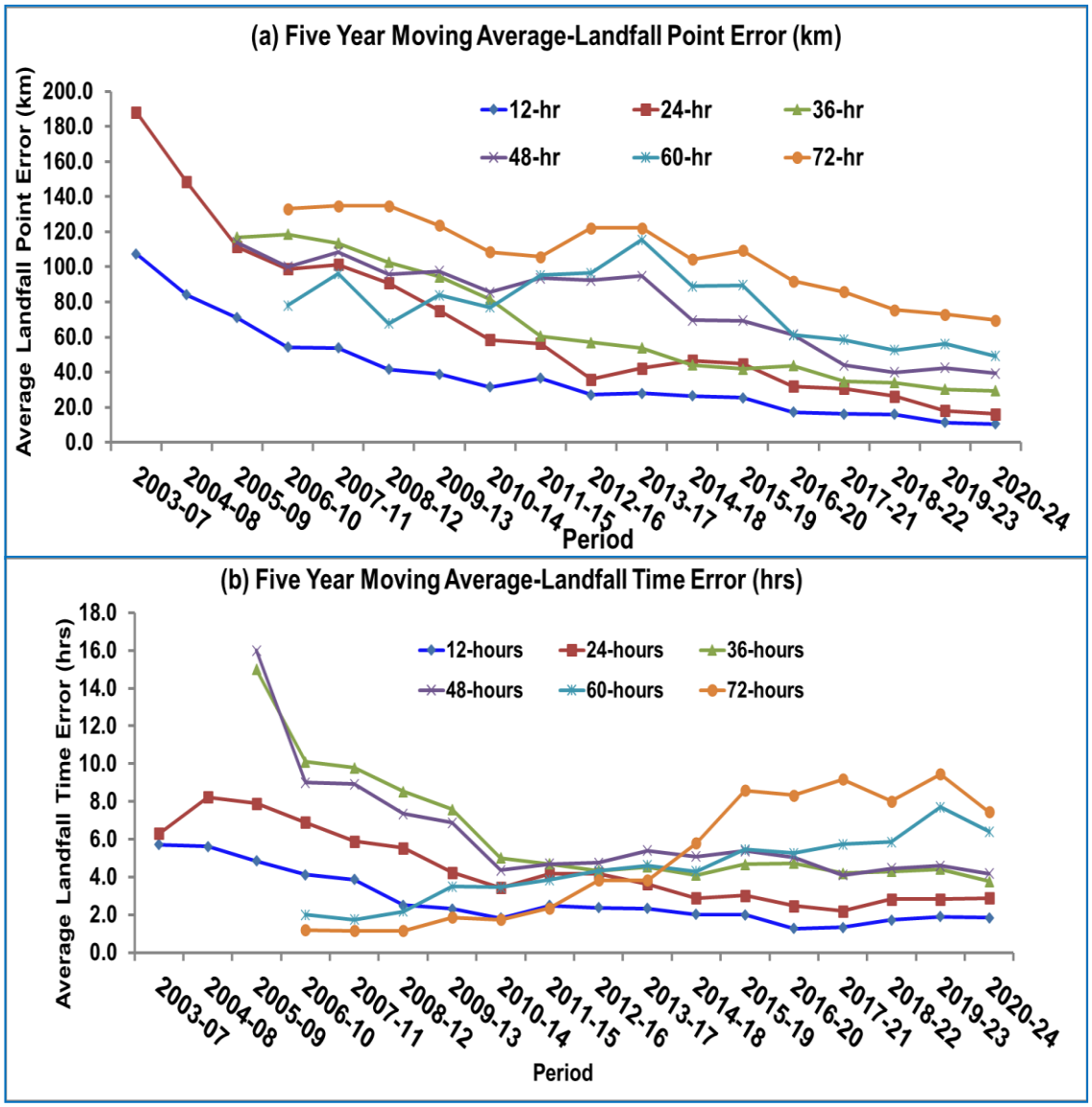


Fig. 24: Five Year Moving Average Errors in (a) Landfall Point (km) and (b) Landfall Time (hrs) of RSMC, New Delhi over north Indian Ocean