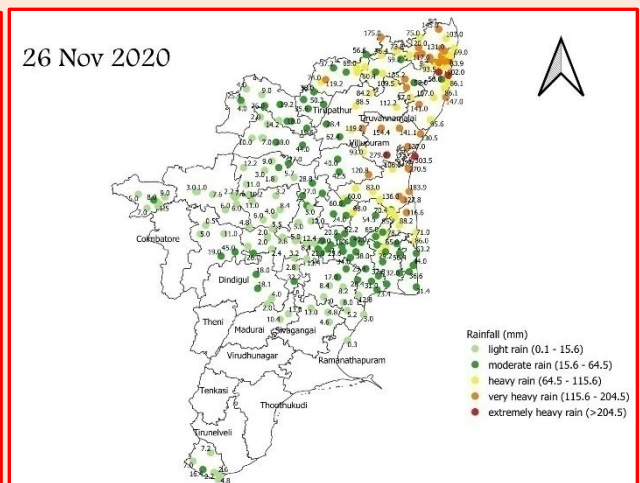
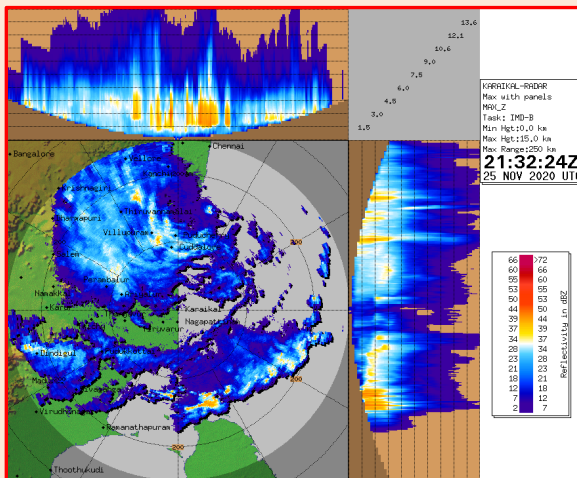
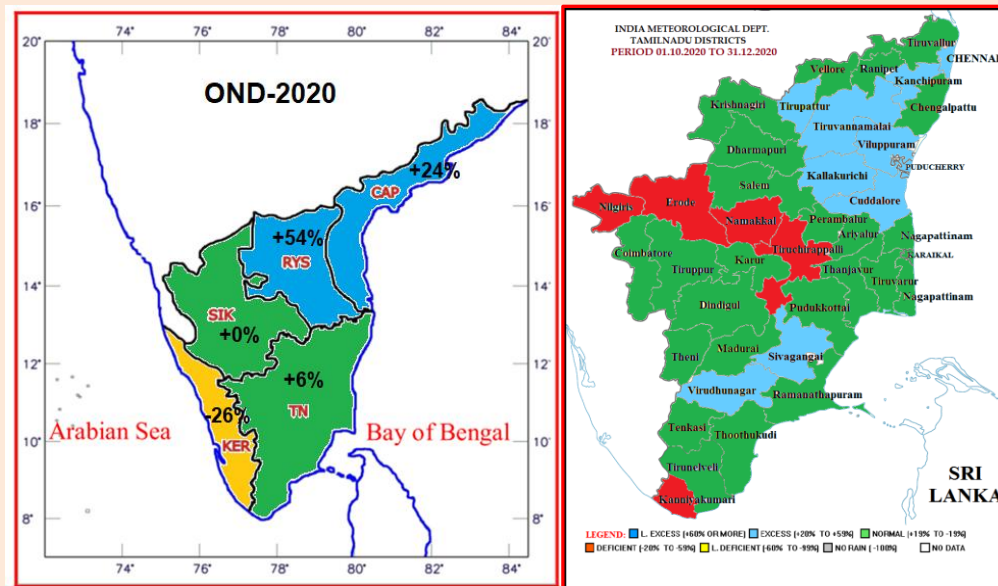




Government of India
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Ministry of Earth Sciences
India Meteorological Department



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REPORT ON NORTHEAST MONSOON – 2020



Regional Meteorological Centre, Chennai
Mar 2021

Table of Contents

1.	Background	5
2.	Onset phase	6
3.	Synoptic scale weather systems	15
3.1	Cyclones and Depressions over BOB	15
3.2	Other synoptic scale systems	34
4.	Sub-divisional rainfall performance	39
4.1	Seasonal rainfall	39
4.2	Monthly, Weekly & Daily rainfall scenario	39
4.3	Monsoon activity and heavy rainfall statistics	42
5.	District rainfall performance	46
6.	Standardised Precipitation Index	48
7.	Chief circulation features	49
8.	Summary	53
	<i>Acknowledgements</i>	54
	<i>Appendices</i>	55

Executive Summary

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Abstract

The Indian northeast monsoon (NEM) is a monsoon confined to parts of southern peninsular India comprising of the meteorological sub-divisions of Tamil Nadu, Puducherry & Karaikal (TN), Kerala & Mahe (KER), Coastal Andhra Pradesh & Yanam (CAP), Rayalaseema (RYS) and South Interior Karnataka (SIK) and occurs during the months of October to December. It is the chief rainy season for the sub-division of TN and the agricultural activities of this region depend on the NEM rainfall. The NEM season is also the chief cyclone season for the North Indian Ocean (NIO) region and the passage of cyclones and depressions over the NIO region significantly affect the NEM performance. As such, aside from the point of view of agricultural planning, this season also assumes significance from the disaster management perspective. Agricultural planners, disaster managers and others seek information on the NEM performance in various spatio-temporal scales. This report presents briefly, the salient features of NEM 2020 over the five meteorological sub-divisions benefitted by the NEM, including the onset phase, synoptic scale weather systems during the season, sub-divisional rainfall performance in seasonal, monthly, weekly and daily scales, monsoon activity and heavy rainfall events, district rainfall performance, standardized precipitation index and the large scale circulation features associated with the NEM activity.

1. Background

The Indian southwest monsoon (SWM) season of June to September is the chief rainy season for India and about 75% of the country's annual rainfall is realised during this season. Subsequent to the withdrawal of SWM, the northeast monsoon (NEM), a monsoon confined to parts of southern peninsular India comprising of the meteorological sub-divisions of Tamil Nadu, Puducherry & Karaikal (TN), Kerala & Mahe (KER), Coastal Andhra Pradesh & Yanam (CAP), Rayalaseema (RYS) and South Interior Karnataka (SIK) occurs. For the subdivision of TN, the normal SWM seasonal rainfall realised is only about 35% (342.0 mm) of its annual rainfall (943.7 mm) as this subdivision comes under the rain-shadow region during the SWM. The northeast monsoon (NEM) season of October to December (OND) is the chief rainy season for this subdivision with 48% (447.4 mm) of its annual rainfall realised during this season and hence its performance is a key factor for this regional agricultural activities.

Further, the NEM season is also the primary cyclone season for the North Indian Ocean (NIO) basin comprising of the Bay of Bengal (BOB) and the Arabian Sea (AS) and cyclonic disturbances (CDs; low pressure systems (LPS) with maximum sustained surface wind speed (MSW) of 17 knots or more) forming over BOB and moving west/northwest-wards affect the coastal areas of southeastern peninsular India and also contribute significantly to NEM rainfall. As such, the NEM season assumes importance from the agricultural as well as cyclone disaster management perspectives.

Prior to the commencement of NEM rains, after the withdrawal of SWM upto 15°N, reversal of low level winds from southwesterly to northeasterly occurs. The normal date of setting in of easterlies over the southeastern peninsular India is 14th October. The normal date of onset of NEM over Coastal TN (CTN) and south CAP is 20th October. The normal rainfall received over the five NEM sub-divisions during OND is TN-447.4 mm, KER-491.6 mm, CAP-338.1 mm, RYS-223.3 mm and SIK-204.1 mm. However, the NEM seasonal rainfall shows a high degree of variability with 27% co-efficient of variation.

The NEM rainfall is influenced by global climate parameters such as ENSO (El Nino/La Nina & Southern Oscillation Index), Indian Ocean Dipole (IOD) and Madden-Julian Oscillation (MJO). El Nino, positive IOD and MJO in phase 2-4 with amplitude greater than one are generally associated with good NEM rainfall. Also, La Nina & positive SOI during the second half of the season is also favourable for good NEM activity.

2. Onsetphase

During October 2020, La Nina and positive SOI conditions prevailed over the equatorial Pacific region; IOD was neutral and MJO was generally in phase 5-8. As such La Nina & positive SOI, and MJO in the western hemisphere were not favourable for good NEM activity. Further, two low pressure systems over the BOB- (i) a Deep Depression (DD) during 11th-14th October 2020 that crossed north Andhra Pradesh coast near Kakinada and (ii) a Depression (D) during 22nd-24th October 2020 that crossed West Bengal – Bangladesh coasts extended the southwest monsoon activity upto the last week of October 2020.

The withdrawal of SWM-2020 upto 15°N took place only on 27th October and further from the entire country on 28th October with simultaneous commencement of NEM rains from 28th October over Tamil Nadu and the adjoining areas of Kerala, Karnataka and Andhra Pradesh. Reversal of surface and low level winds from westerly to easterly over the southeastern parts of peninsular India took place on 28th October with the withdrawal of SWM from the entire country and under the influence a cyclonic circulation off Tamil Nadu – south Andhra Pradesh coast. Pentad mean wind during the pentads 21st-25th October and 26th-30th October, surface isobaric analysis as on 0830 IST of 28th October and upper air streamline analysis based on 0530 IST observations of 24th and 28th October depicting the synoptic situation and reversal of zonal westerlies to easterlies off north Tamil Nadu – Andhra Pradesh coast in association with a cyclonic circulation off the coast during the onset of NEM 2020 are presented on Fig.1a-c.

INSAT-3D imageries as on 0530 IST of 24th and 27th October, 0830 & 1730 IST of 28th October and 1730 IST 05th November and 0830 IST of 6th November 2020 depicting the cloudiness prior to, on the date of the onset and about a week after the onset are presented in Fig.1d. Spatial rainfall distribution over the NEM region depicted by IMD gridded/ satellite+gauge merged rainfall and that over TN subdivision based on gauge observation as on 24-hr ending 0830 IST of 06th and 07th November 2020 are presented in Fig.1e&f respectively.

It is noted that the onset of NEM 2020, under unfavourable background setting of La Nina and MJO in the western hemisphere and unfavourable flow pattern under extended SWM conditions, took place as a weak pulse on 28th October under the influence of a cyclonic circulation over the southwest BOB off north Tamil Nadu coast extending up to 3.1 km above mean sea level. Rainfall was reported at isolated or at a few places over the TN subdivision during 28th October -05th November. However, heavy to very heavy rain was reported at isolated places along the coastal and the southern districts during this period. During the 24-hr ending 0830 IST of 29th October, heavy to very heavy rain occurred in the coastal districts including Chennai, Tiruvallur, Chengalpattu, Toothukudi and Ramanathapuram districts. Gradually the NEM picked up by the first week of November with rainfall occurring at many places over TN on 06th November 2020.

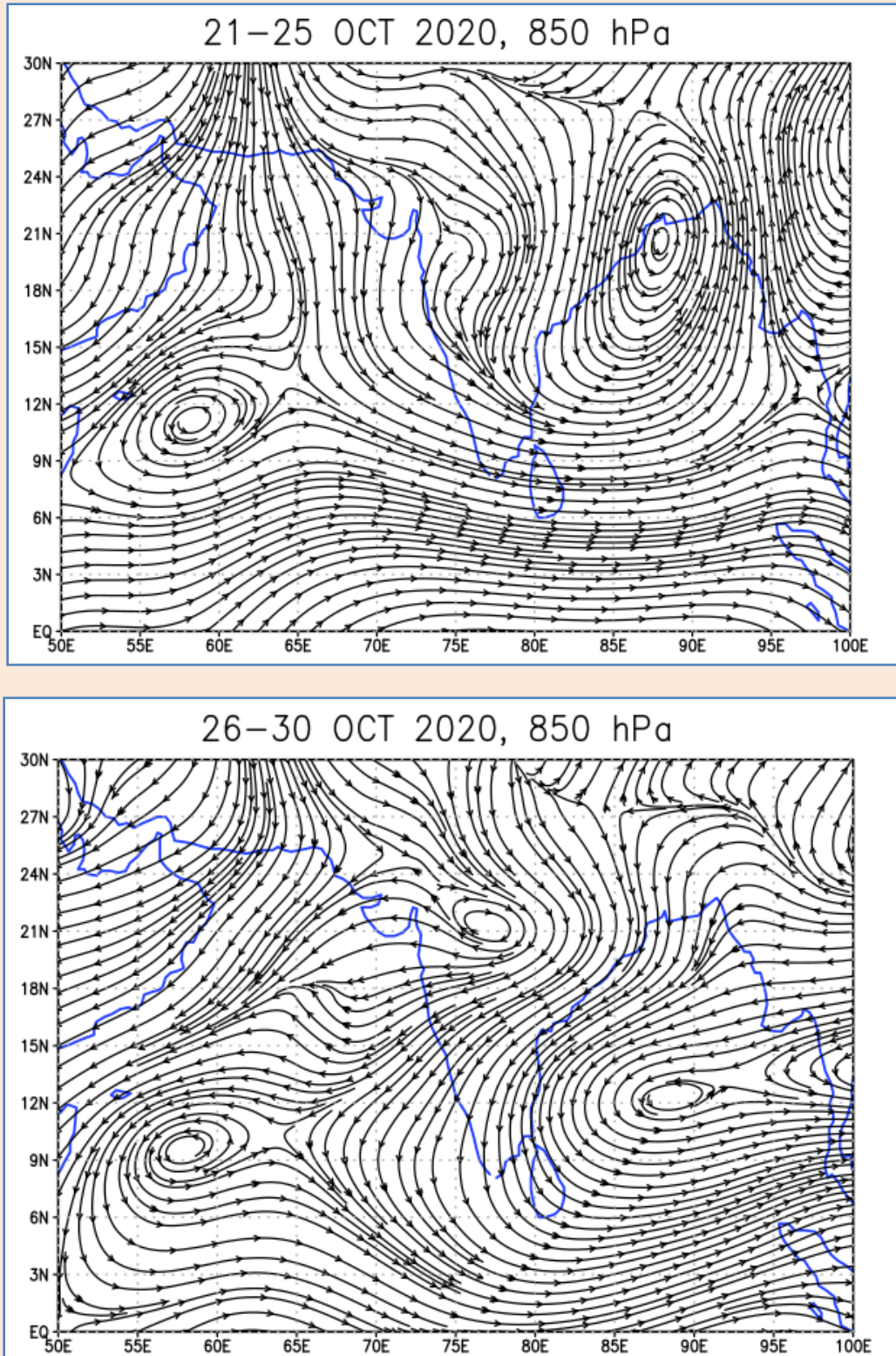
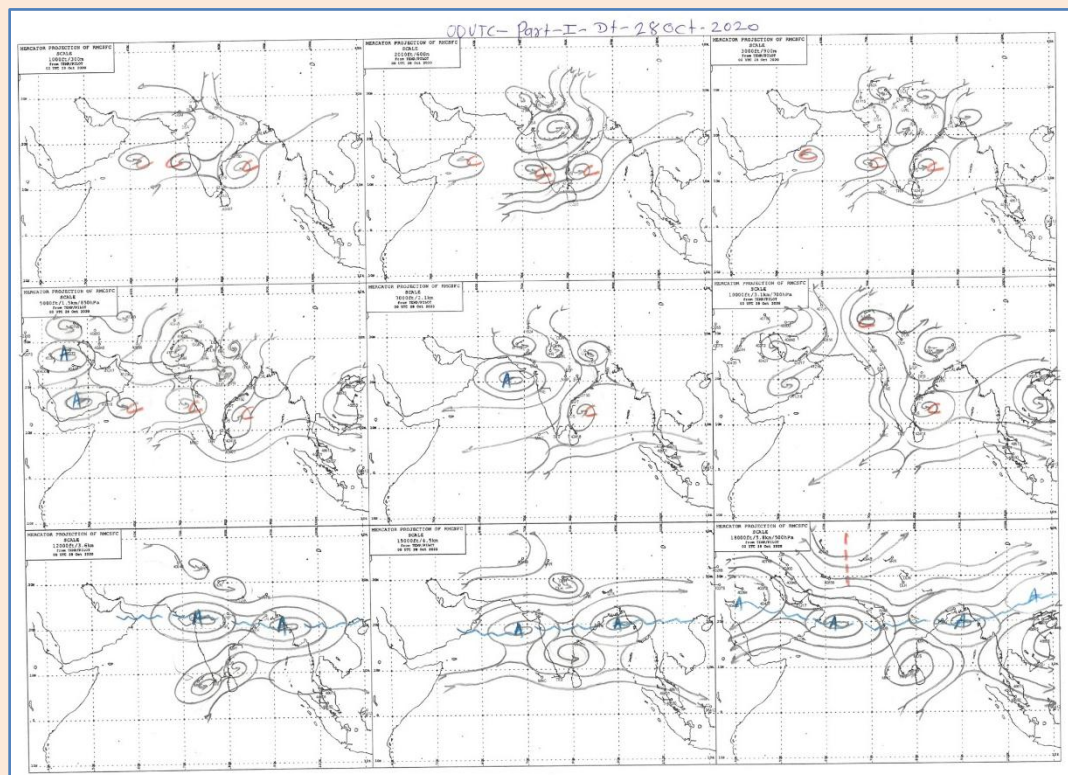
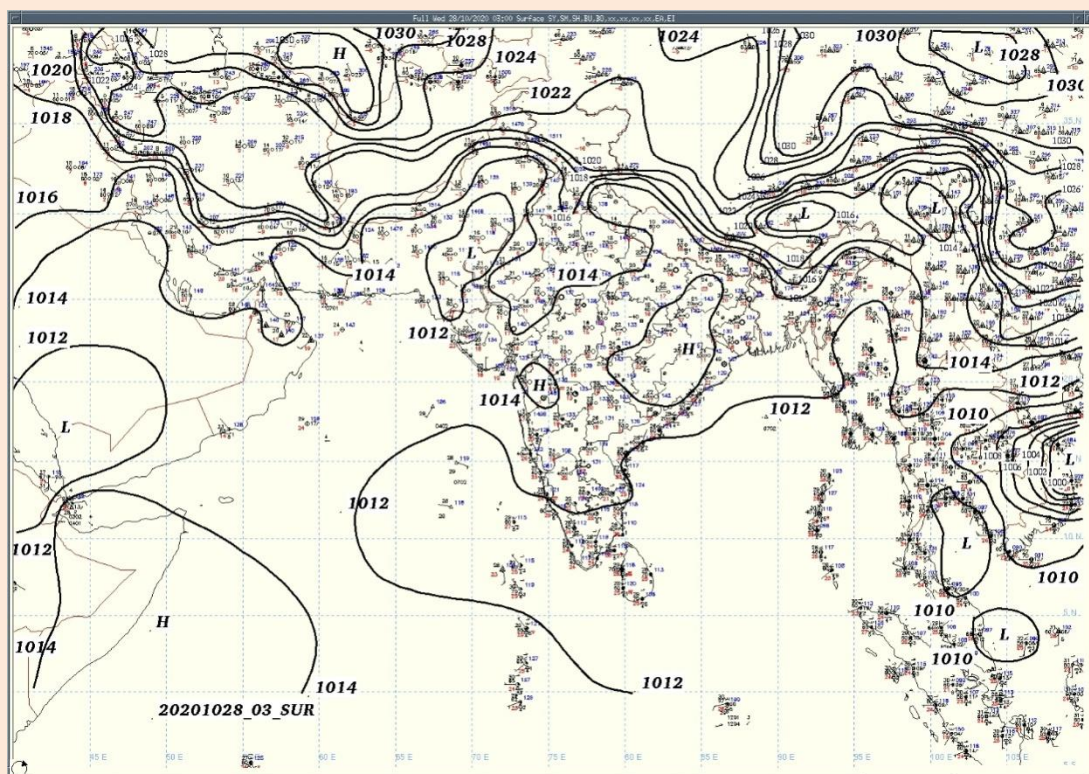


Fig.1a: NCEP reanalysis 850 hPa streamline pattern indicating reversal wind from westerly to easterly over peninsular India during the sixth pentad (26th-30th) of October 2020



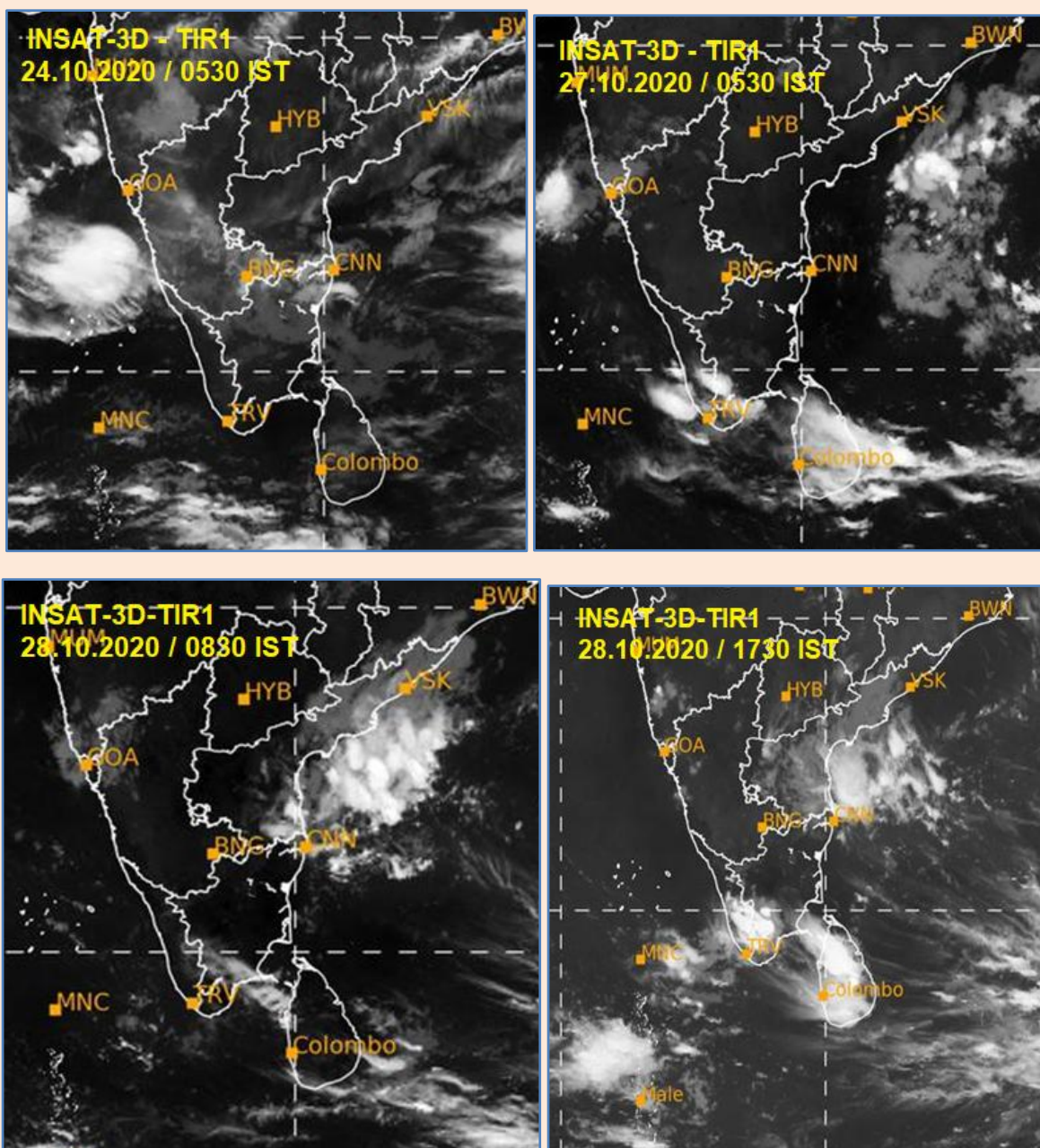


Fig.1d: INSAT-3D infra-red imageries as on 24/0530, 27/0530, 28/0830, 28/1730 IST of October 2020 and 05/1730 and 06/0830 IST of November 2020.

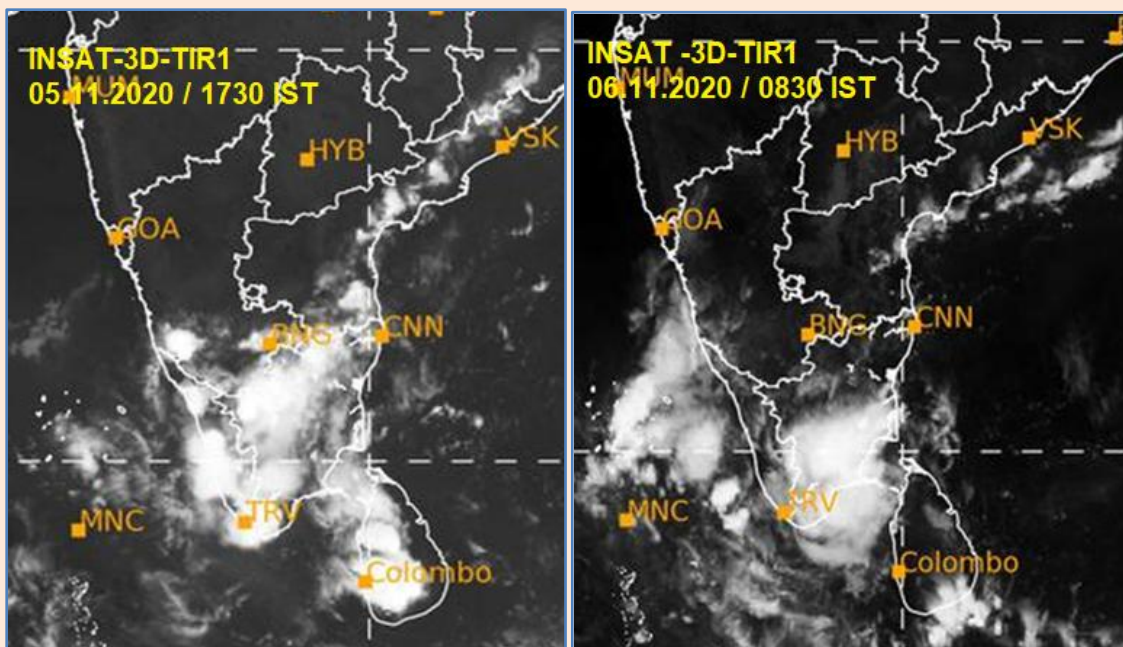


Fig.1d: contd.

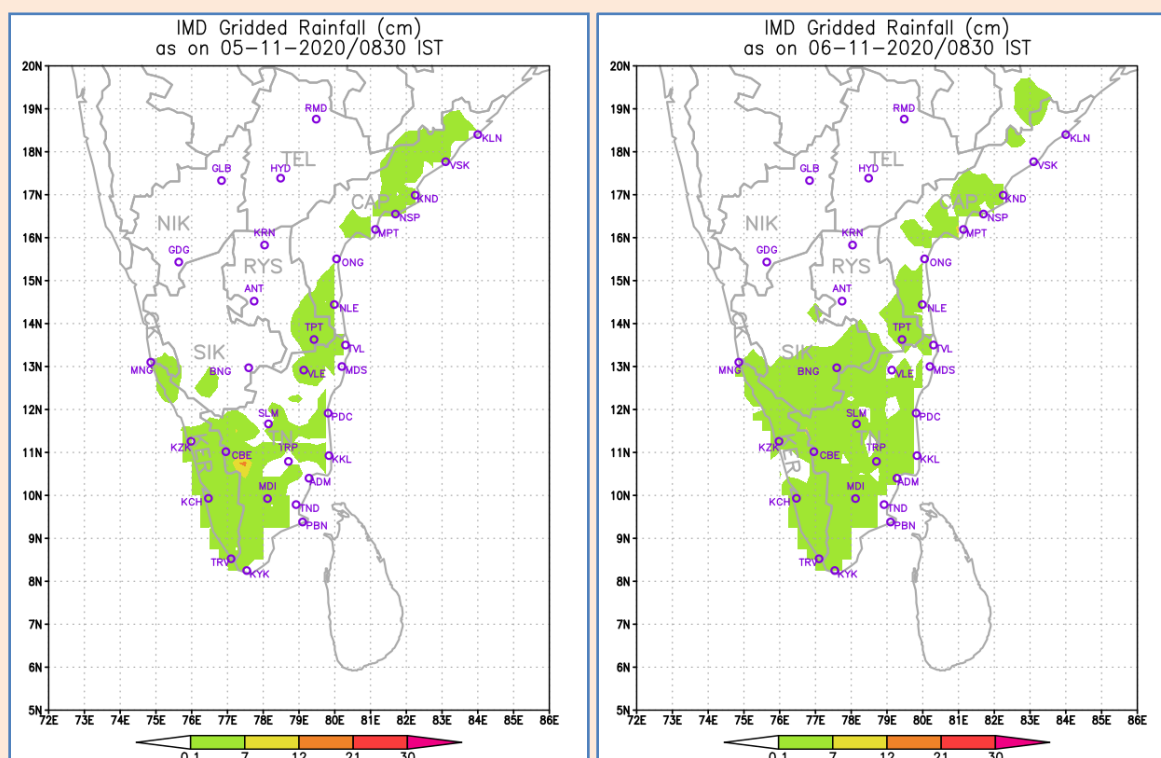
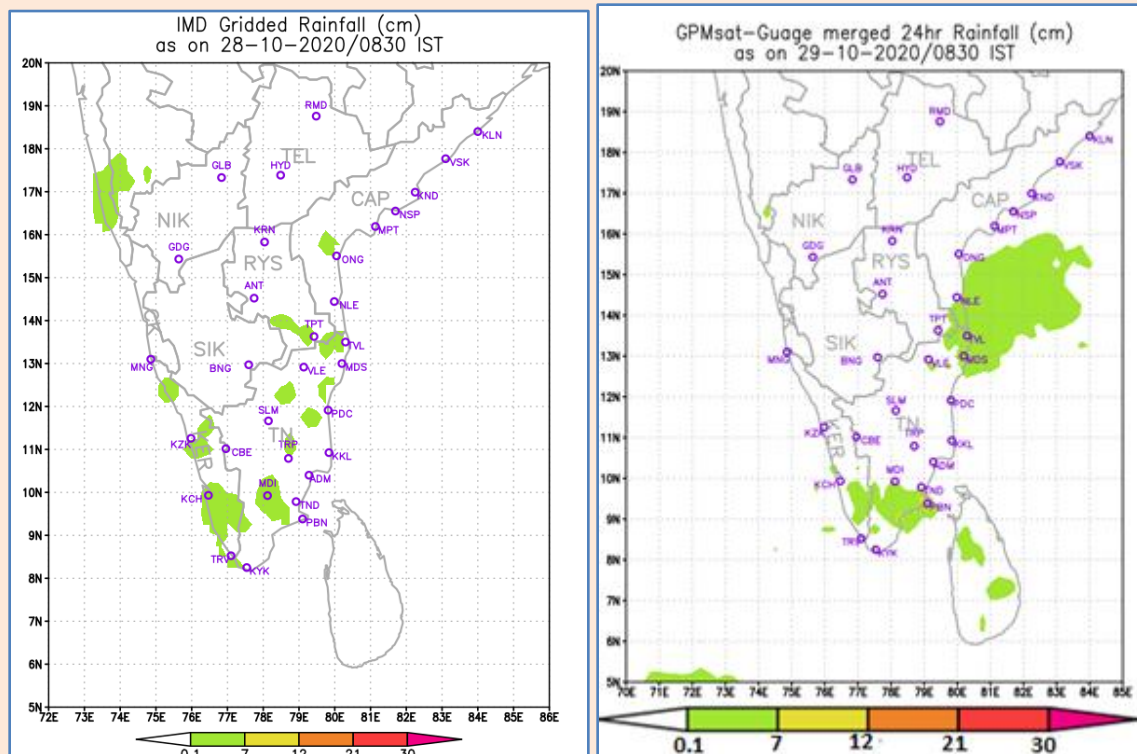


Fig.1e: IMD gridded / sat+gauge merged rainfall (in cm) as on 24-hr ending 0830 IST of 28 & 29 Oct and 05 & 06 Nov2020.

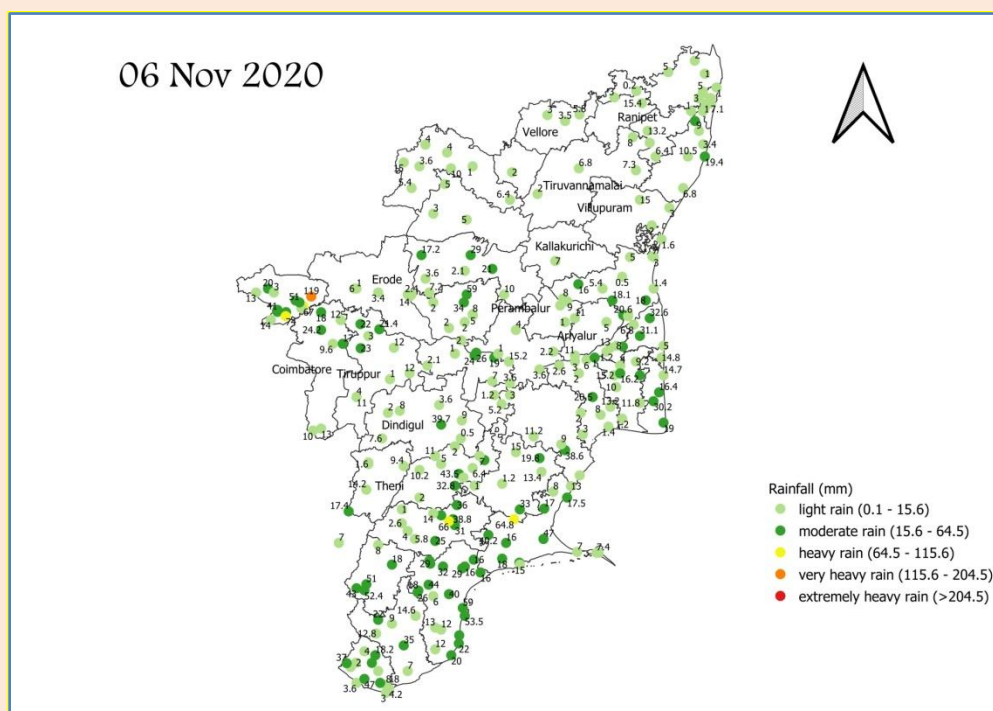
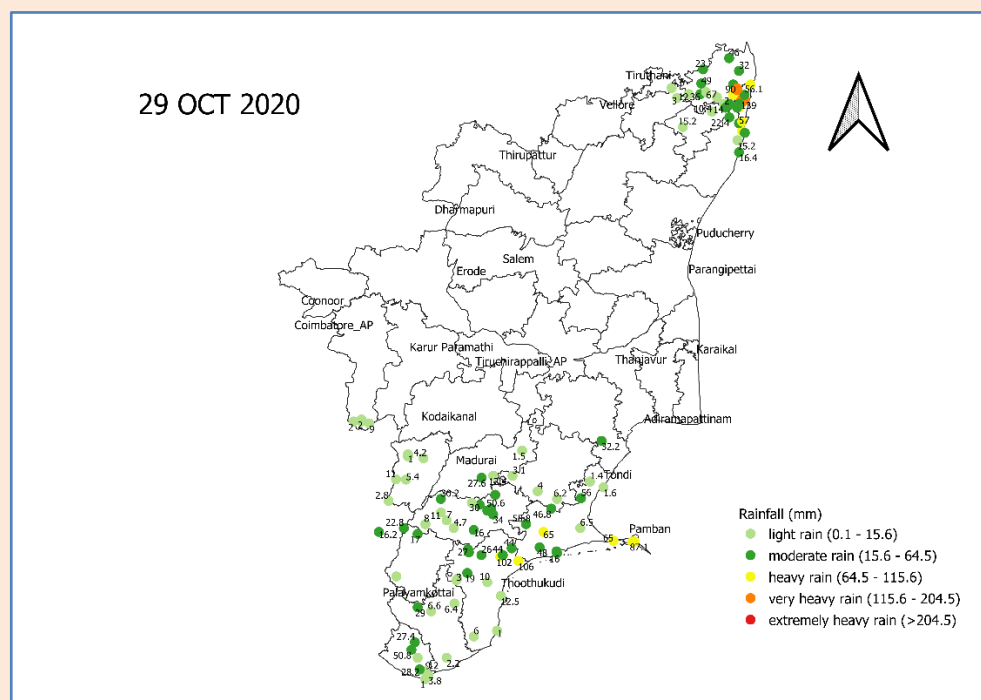


Fig.1f: Rainfall distribution (in mm) over TN based on point rainfall observation (rain gauge) as on 24-hr ending 0830 IST of 29 Oct & 6 Nov 2020.

3. Synoptic scale weather systems during the NEM-2020 season

3.1 Cyclones and Depressions over the Bay of Bengal

During October-December 2020, six major low pressure systems (LPS) formed over the NIO – four over the BOB and two over the AS. Of these the four LPS that formed over the BOB influenced the NEM activity. Brief life history of these four LPS (based on the preliminary reports on these LPS of RSMC, IMD New Delhi) - (i) Deep Depression over the BOB during 11th – 14th October 2020 (ii) Depression over the BOB during 22nd – 24th October 2020 (iii) Very Severe Cyclonic Storm (VSCS) *NIVAR* over BOB during 22nd – 26th November 2020 and (iv) Cyclonic Storm (CS) *BUREVI* over the BOB during 30th November – 05th December 2020 and their influence on the NEM activity is presented below:

(i) **Deep Depression over the BOB during 11th – 14th October 2020:** This LPS originated from a low pressure area (LOPAR) that formed over north Andaman sea in the early morning of 09th October (0530 IST). It concentrated into a depression (D) over westcentral BOB in the early morning of 11th (0530 IST). Moving west-northwestwards, it intensified into a DD in the forenoon of 12th (1130 IST) and crossed north Andhra Pradesh coast close to Kakinada (near Lat. 17.0°N & Long 82.4° E) between 0630 & 0730 hrs IST of 13th October 2020, as a DD with a maximum sustained wind speed of 55-65 kmph gusting to 75 kmph. Continuing to move west-northwestwards, it weakened into a D over Telangana in the forenoon (1130 IST) of 13th October and into a Well Marked Low pressure area in the evening (1730 IST) of 14th October 2020 over South Madhya Maharashtra and neighbourhood. The track of the system and INSAT-3D imagery as on 27th October / 1730 IST are presented in Fig.2a.

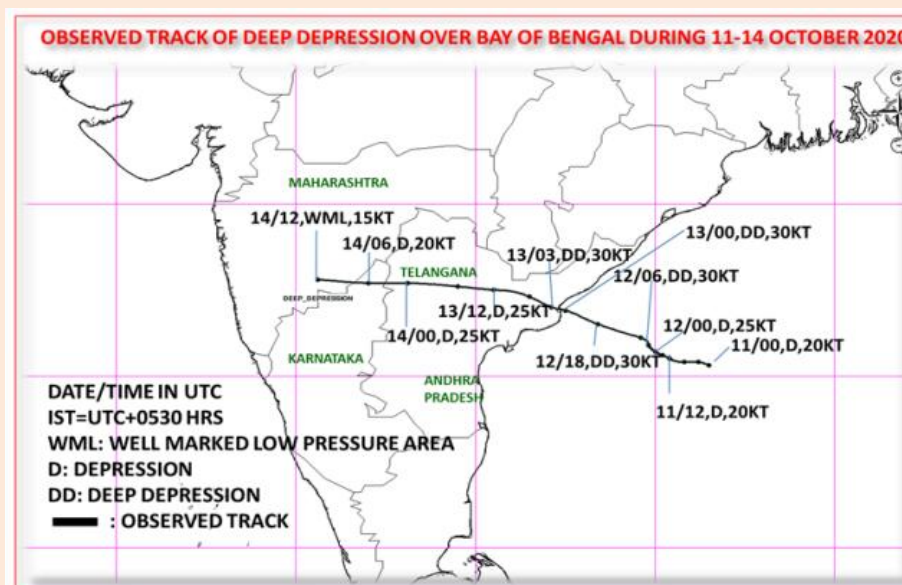


Fig.2a: Track of the Deep Depression during 11-14 Oct 2020

(ii) Depression over the BOB during 22nd – 24th October 2020: This LPS originated as a LOPAR over central parts of BOB, in the early morning (0530 IST) of 20th October 2020 and became a well marked low pressure area over west-central BOB in the morning (0830 IST) of 21st October. Under favourable environmental conditions, it concentrated into a Depression over northwest & adjoining west-central BOB in the morning (0830 IST) of 22nd October. It initially moved northwards for some time and thereafter moved north-northeastwards and crossed West Bengal & adjoining Bangladesh coasts over Sundarbans near latitude 21.8°N and longitude 88.5°E around noon of 23rd October 2020 as a Depression with maximum sustained wind speed of 45-55 kmph gusting to 65 kmph. Further moving north-northeastwards, it weakened into a well marked low pressure area over central Bangladesh & neighbourhood in the early morning of 24th October 2020. The track of the system is shown in Fig.2b.

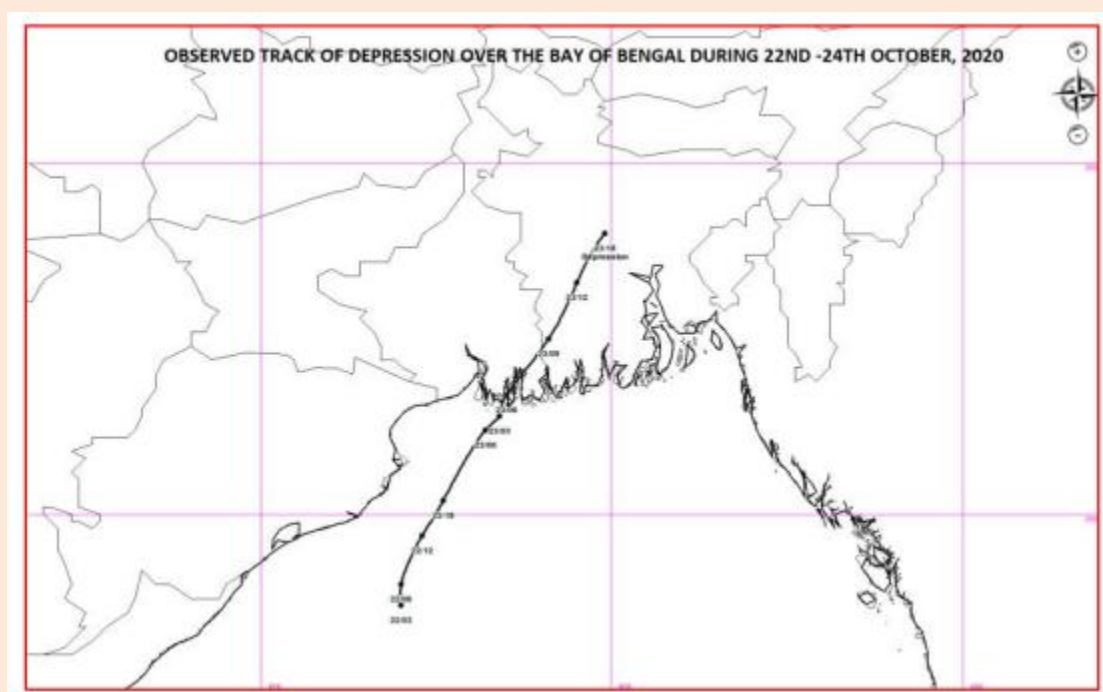


Fig.2b:Track of the Depression over the BOB during 22-24 Oct 2020

As mentioned earlier, under the influence of the above two LPSs, rainfall activity continued over Telangana and adjoining Karnataka which extended the SWM activity and delayed the setting in of easterlies over the southeastern parts of the peninsular India leading to poor NEM activity during October 2020.

(iii) Very Severe Cyclonic Storm (VSCS) NIVAR over BOB during 22nd – 26th November 2020: VSCS NIVAR formed as a LOPAR over Equatorial Indian Ocean (EIO) and adjoining central parts of south BOB on 21st November. It lay as a Well Marked LOPAR (WML) over southwest & adjoining southeast BOB on 22nd November and concentrated into a D over the same region in the early hours (0230 IST) of 23rd November. Moving west-northwestwards, it intensified into a DD in the evening of 23rd and further into the cyclonic storm NIVAR in the

early morning (0530 IST) of 24th November over the southwest BOB. Continuing to move west-northwestwards, it further intensified into a severe cyclonic storm in the midnight (2330 hrs IST) of 24th and into a very severe cyclonic storm in the afternoon (1430 hrs IST / 0900 UTC) of 25th November. Moving further northwestwards, it crossed Tamil Nadu & Puducherry coasts near Puducherry (near lat. 12.1°N and long. 79.9°E) during 2330 IST of 25th to 0230 IST of 26th as a very severe cyclonic storm with estimated wind speed of 120kmph gusting to 135 kmph. Continuing to move northwestwards, it weakened into a severe cyclonic storm in the early morning hours (0230 IST) of 26th November. Thereafter, it moved north-northwestwards and weakened into a cyclonic storm in the morning (0830 IST) of 26th November, 2020 over north coastal Tamil Nadu. Subsequently, it gradually recurved north-northeastwards and weakened into a deep depression in the afternoon (1430 IST) of 26th over south Rayalaseema and further into a depression in the same midnight (2330 IST) over south coastal Andhra Pradesh. It then weakened into a well marked low pressure area over south coastal Andhra Pradesh and adjoining westcentral BOB in the early morning (0530 IST) of 27th November 2020. Under its influence, intense rainfall activity occurred over north Tamil Nadu & Puducherry, Rayalaseema and south coastal Andhra Pradesh during 26th-27th November 2020. The track of the system is shown in Fig.2c(i). Surface isobaric analysis as on 0830 IST and upper air streamline analysis as on 0530 IST of 25th and 26th November are presented in Fig.2c(ii)a-d. INSAT-3D imagery showing the system as on 0530 IST of 25th November is presented in Fig.2c(iii) and maximum reflectivity products of Doppler Weather Radar (DWR) at Chennai & Karaikal as on 0130 IST & 0300 IST of 26th November 2020 respectively are presented in Fig.2c(iv).

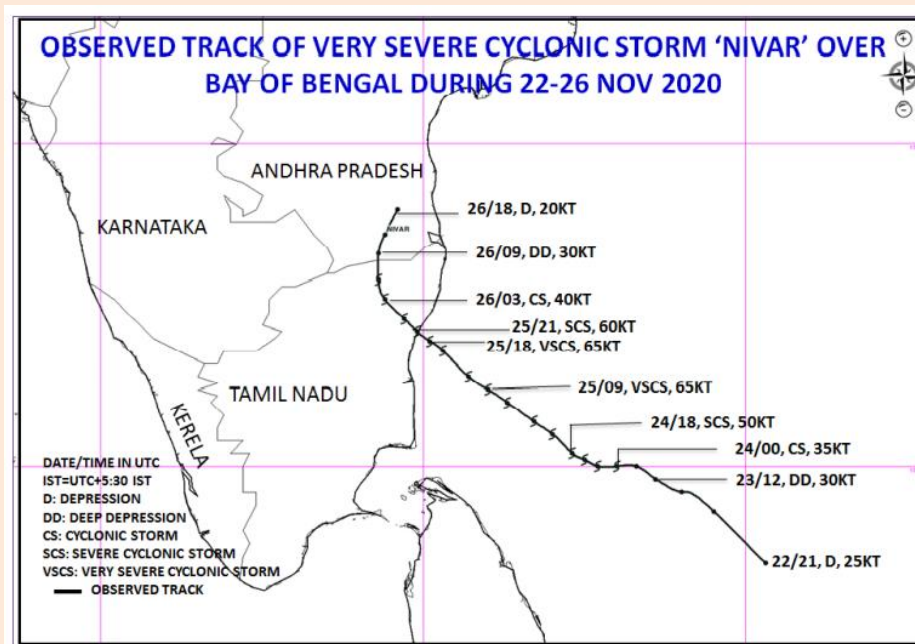
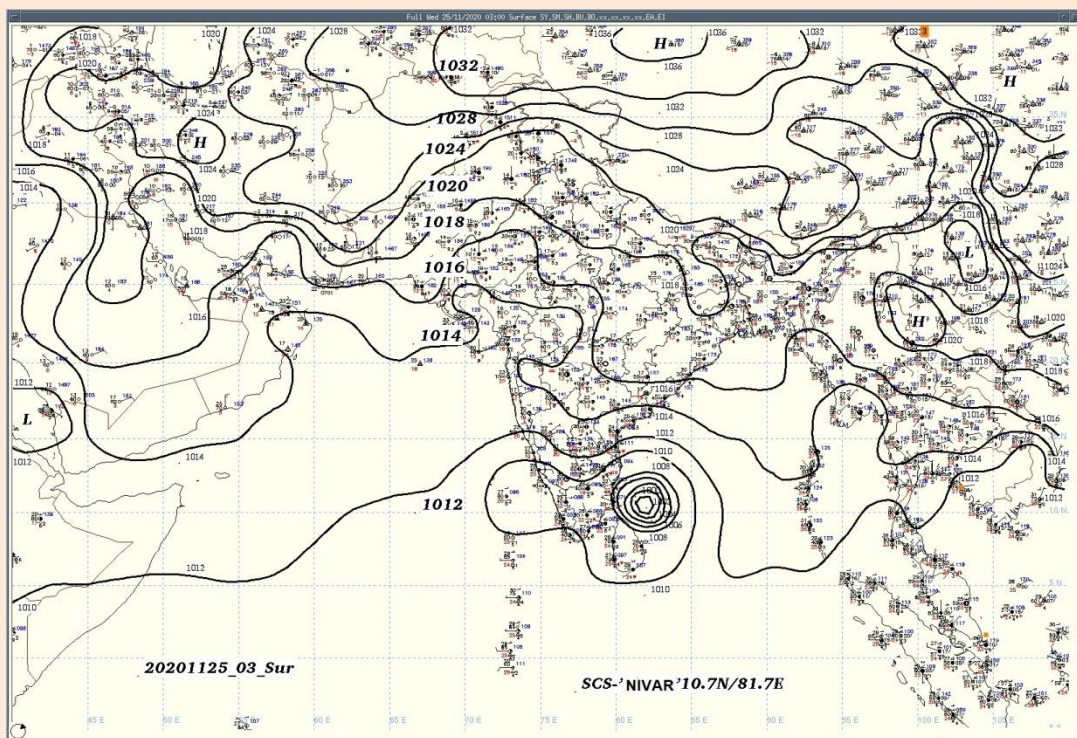
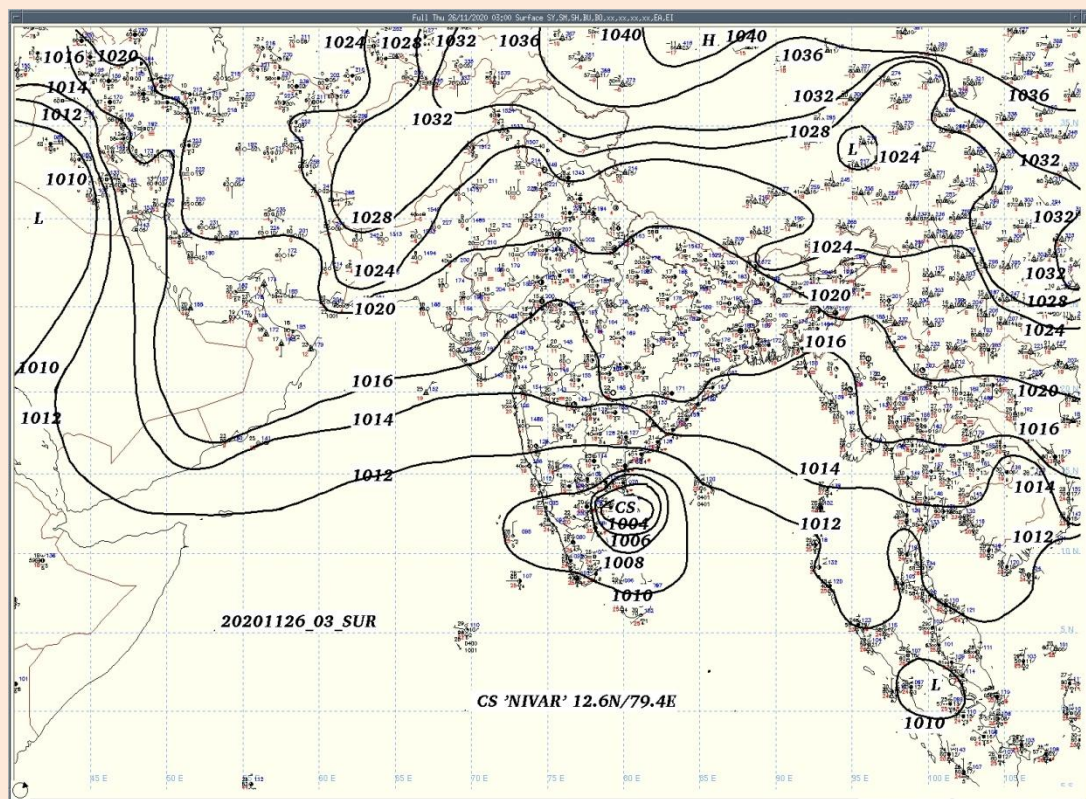


Fig.2c(i): Track of the VSCS NIVAR during 22-26 November 2020



(a)



(b)

Fig.2c(ii) Surface isobaric analysis indicating the location of the system as on (a) 25 Nov 2020 / 0830 IST &(b) 26 Nov 2020 / 0830 IST.

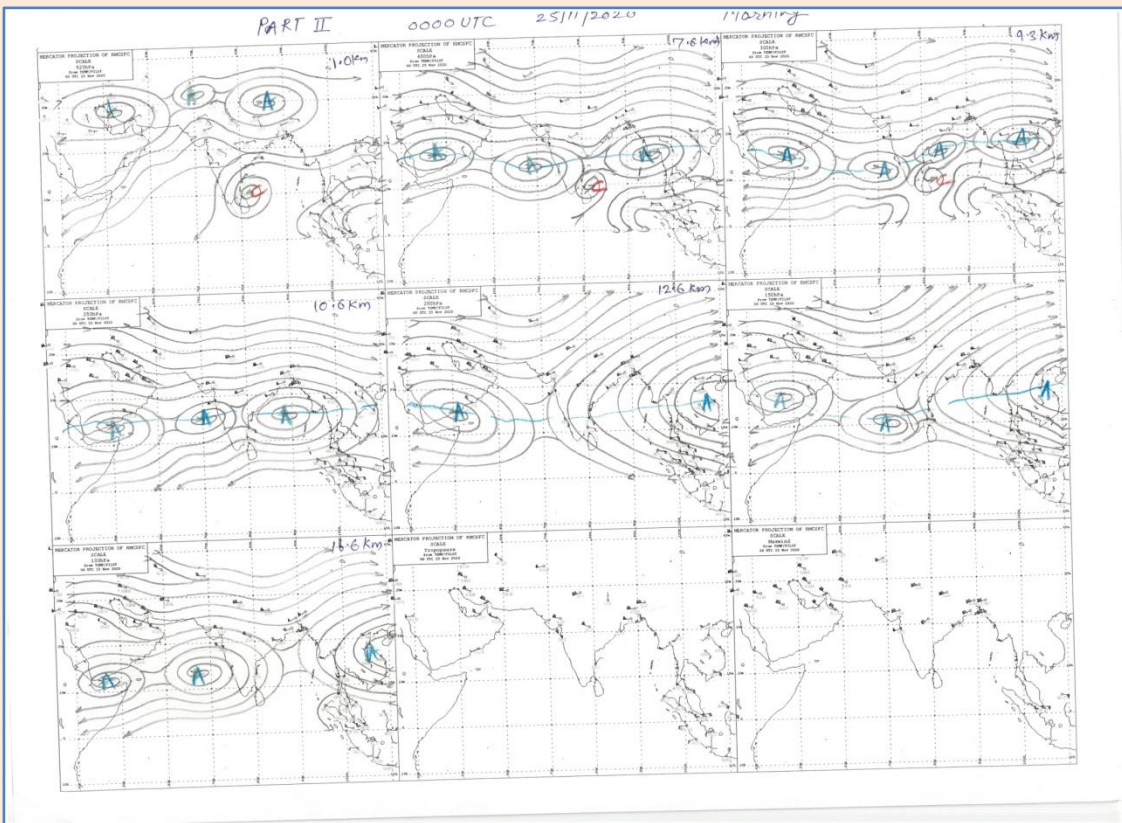
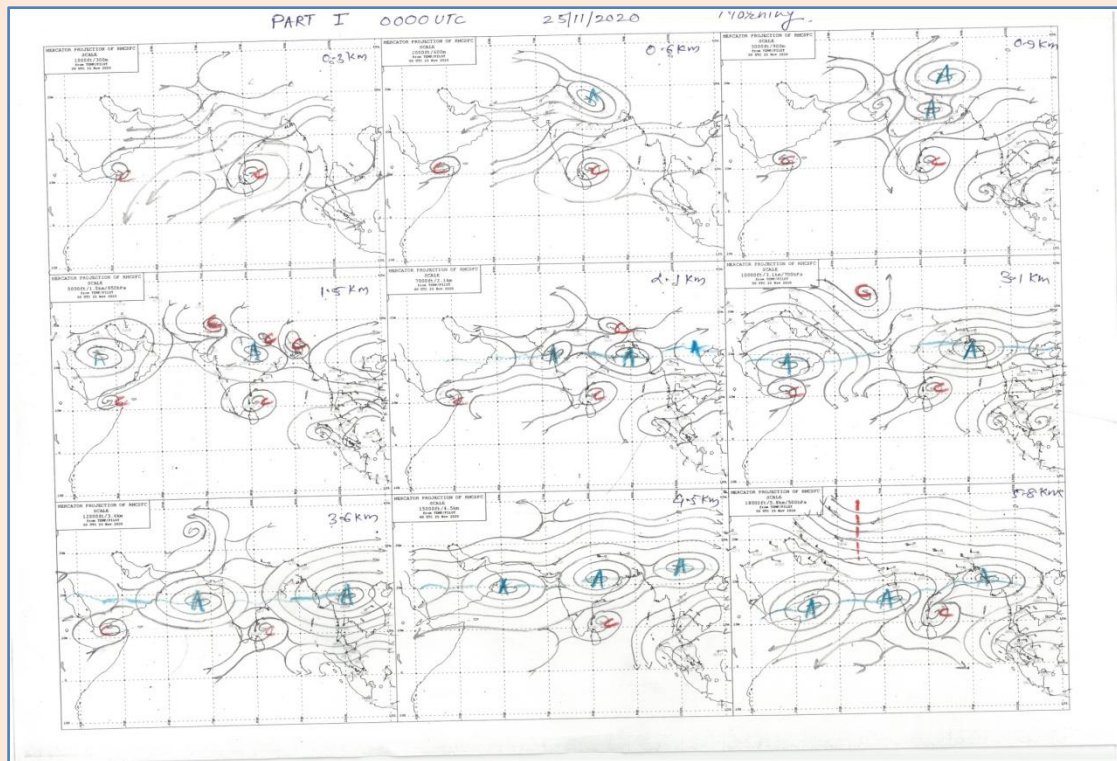


Fig.2c(ii)-c Upper air streamline analysis indicating the cyclonic circulation associated with the system as on 25 Nov 2020 / 0530 IST.

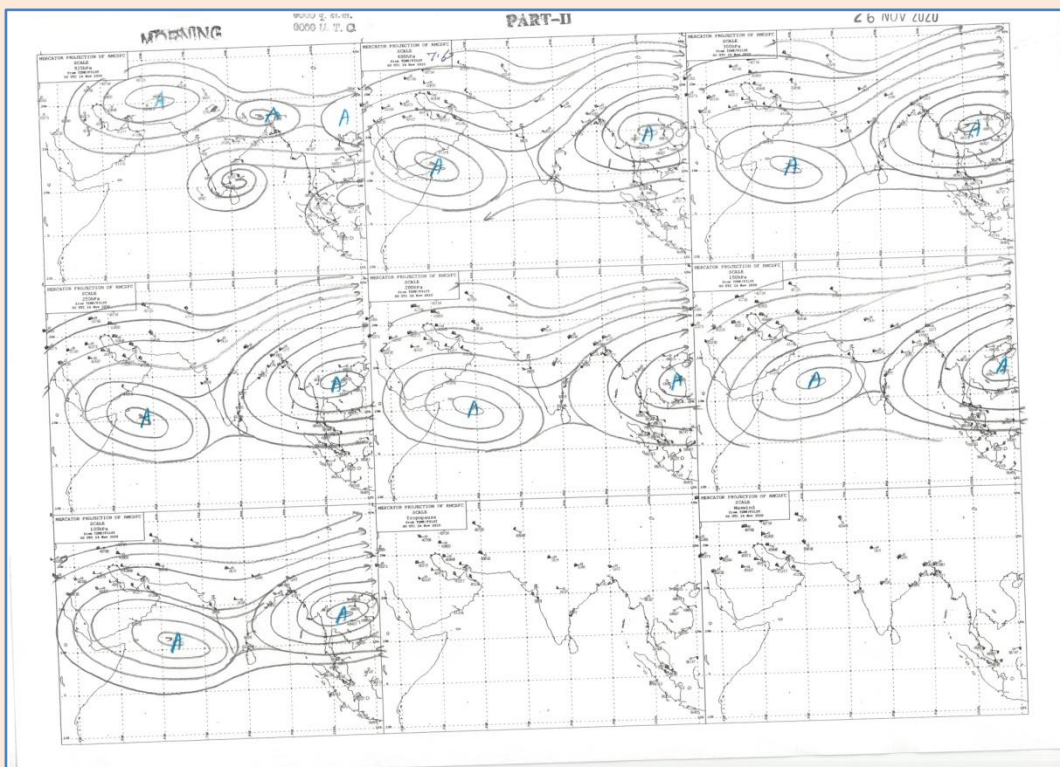
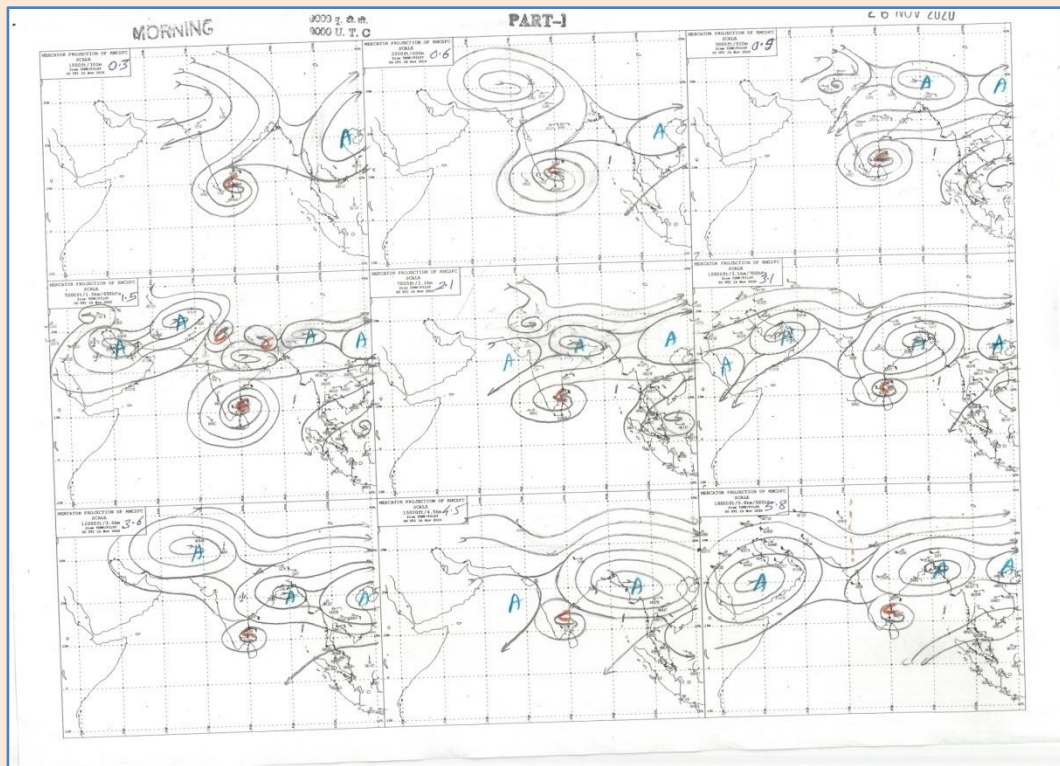


Fig.2c(ii)-d Upper air streamline analysis indicating the cyclonic circulation associated with the system as on 26 Nov 2020 / 0530 IST.

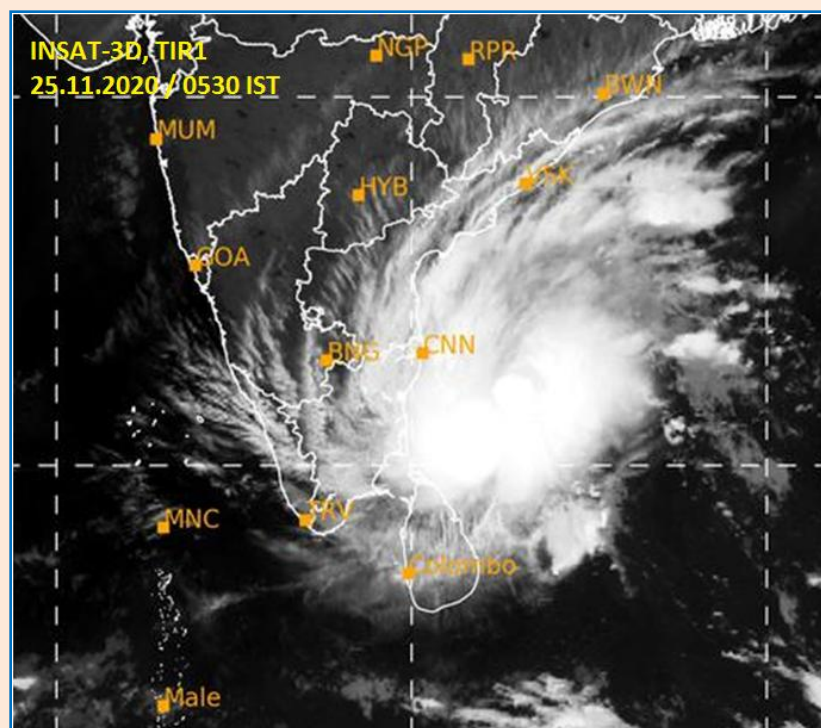


Fig.2c(iii): INSAT-3D imagery of VSCS NIVARas on 0530 IST of 25th November 2020

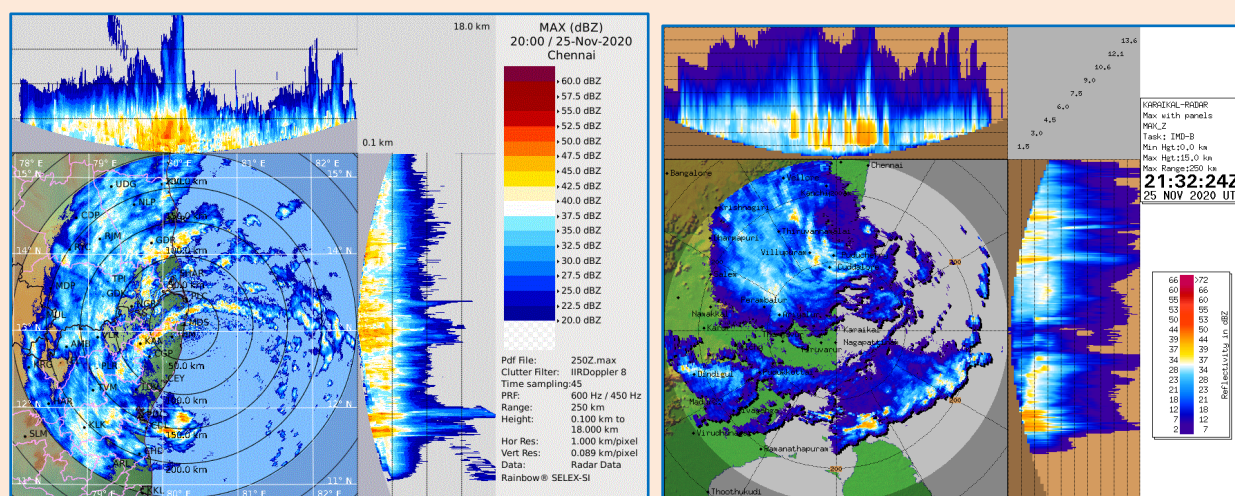


Fig.2c(iv): Maximum reflectivity product of Doppler Weather Radars at Chennai Karaikal and Chennai in the early hours (0130 IST & 0300 IST respectively) of 26th November 2020

It is noted that when the system approached the coast, it had vertical extension up to 9.5 km a.s.l and was influenced by an upper air westerly trough in the mid troposphere. Due to interaction with the upper air westerly trough, the upper part of the system was stretched northeast –wards along the coast as indicated in the as on satellite based vorticity field during the early hours of 26th November [Fig.2c(v)a] and INSAT-3D imagery as on 26th November /2000 IST [Fig.2c(v)b]. As such intense rainfall belt associated with the system extended to south Andhra

Pradesh coast and Rayalaseema region also. IMD gridded rainfall and GPM sat+gauge merged rainfall as on 24-hr ending 0830 IST of 25th and 26th November 2020 depicting the regions of heavy rainfall are presented in Fig.2c(vi). The rainfall distribution over the TN subdivision on 26th November 2020 is shown in Fig.2c(vii).

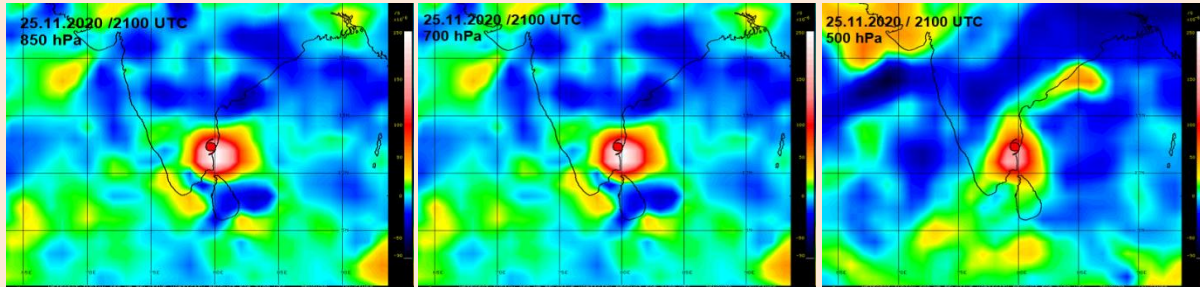


Fig.2c(v)-a: Vorticity at 850 hPa, 700 hPa & 500 hPa associated with the cyclone NIVAR as on 0230 IST of 26th November 2020 (Source: CIMSS Tropical cyclones)

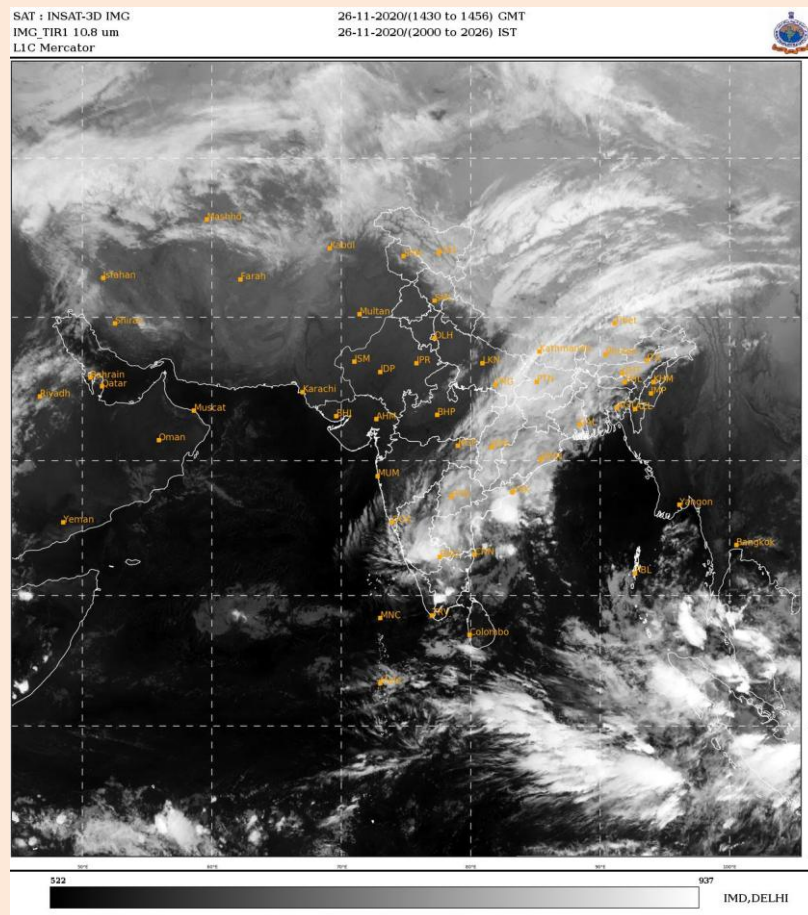


Fig.2c(v)-b: INSAT-3D infra-red imagery as on 26 Nov 2020 /2000 IST

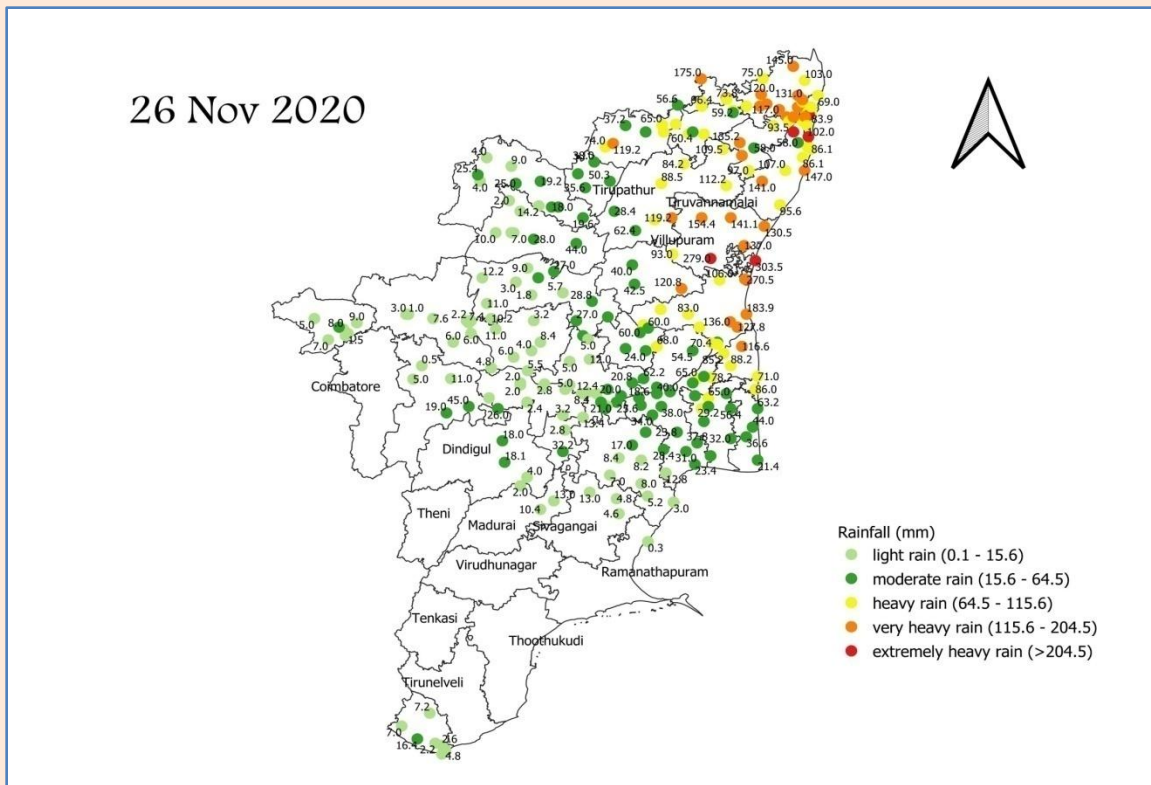


Fig.2c(vii): Gauge rainfall distribution over TN as on 24-hr ending 0830 IST of 26 Nov 2020

It is observed that heavy to very heavy rainfall occurred over Cuddalore, Ngapattinam, Karaikal, Villupuram, Kallakurichi, Puducherry, Chengalpattu, Kanchipuram, Thiruvannamalai, Chennai, Thiruvallur, Vellore and Ranipet districts of TN during the 24-hr ending 0830 IST of 26th November 2020. Extremely heavy rainfall was also reported at isolated places – Tambaram (Chengalpattu district) – 31 cm, Puducherry – 30 cm, Villupuram – 28 cm, Cuddalore – 27 cm, Chennai – Mylapore (DGP office) – 26 cm, Sholinganallur (Chennai district) – 22 cm during the same period. In Nellore district of CAP, Venkatagiri reported 24 cm of rain and Kodur in Cuddapah district of RYS reported 25 cm on 26th and Kavali reported 27 cm on 27th.

As such, associated with the passage of the cyclone NIVAR, about 13% of the seasonal normal rainfall of the TN subdivision was realised during the 5-day period 23rd-28th November 2020 with Chennai, Vellore, Ranipet and Tirupattur recording more than 40% of seasonal normal rainfall of the respective districts [Fig.2c(viii)]. The system caused extensive damages and inland flooding in TN, Rayalaseema and south coastal AP. Some damages associated with the passage of NIVAR are shown in Fig.2c(ix).

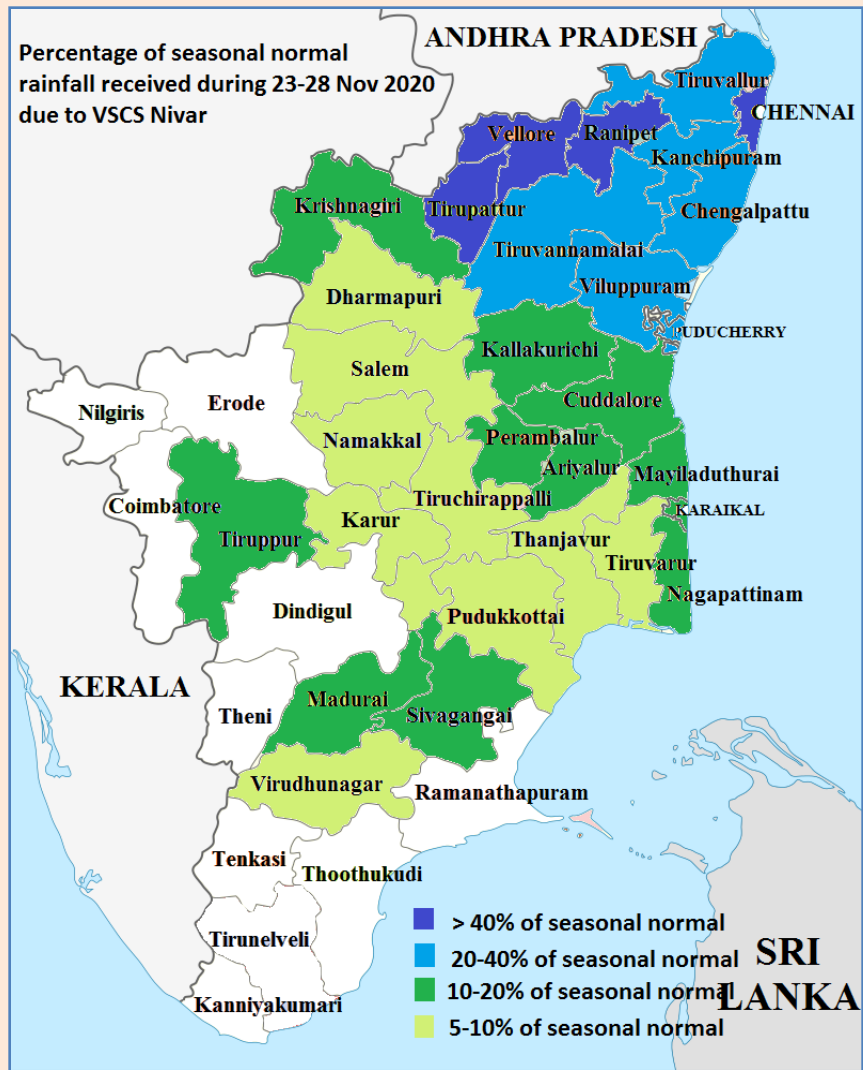


Fig.2c(viii): Percentage of seasonal normal rainfall received during 23-28 Nov 2020 in association with the passage of VSCS NIVAR.



Fig.2c(ix): Some damages associated with the passage of VSCS NIVAR over Tamil Nadu and Puducherry

(iv) Cyclonic Storm (CS) BUREVI over the BOB during 30th November – 05th December 2020: CS BUREVI formed as a LOPAR over South Andaman Sea and Equatorial Indian Ocean on 29th November 2020. Under favourable environmental conditions, it concentrated into D in the early morning (0530 IST) of 30th November over Southeast Bay of Bengal. Moving nearly

westwards, it intensified into a DD in the early morning of 01st December over Southwest and adjoining Southeast Bay of Bengal. Subsequently it moved west-northwestwards and intensified into Cyclonic Storm *BUREVI* over Southwest Bay of Bengal in the evening (1730 IST) of 01st December. Continuing the west-northwestward movement, it crossed Sri Lanka coast close to north of Trincomalee near Lat. 8.85°N and Long. 81.0°E between 2230 and 2330 IST of 2nd December as a Cyclonic Storm with maximum sustained wind speed of 80-90 kmph gusting to 100 kmph. Moving across northern parts of Sri Lanka, it emerged into Gulf of Mannar in the morning of 3rd December and lay centred close to Pamban around noon (1130 IST) and crossed Pamban area around 1330 IST of 3rd December. Continuing to move west-northwestwards, it weakened into a Deep Depression over the same region in the evening (1730 IST) of 03rd December. Thereafter its movement slowed down significantly and it remained practically stationary over Gulf of Mannar close to Ramanathapuram district coast for nearly 18 hours and further weakened into a Depression in the evening of 04th December over the same region. The track of the CS *BUREVI* is shown in Fig.2d(i). Surface isobaric analysis as on 0830 IST and upper air streamline analysis as on 0530 IST of 03rd and 04th December are presented in Fig.2d(ii)a-d. INSAT-3D imagery showing the system as on 0330 IST of 04th December is presented in Fig.2d(iii)

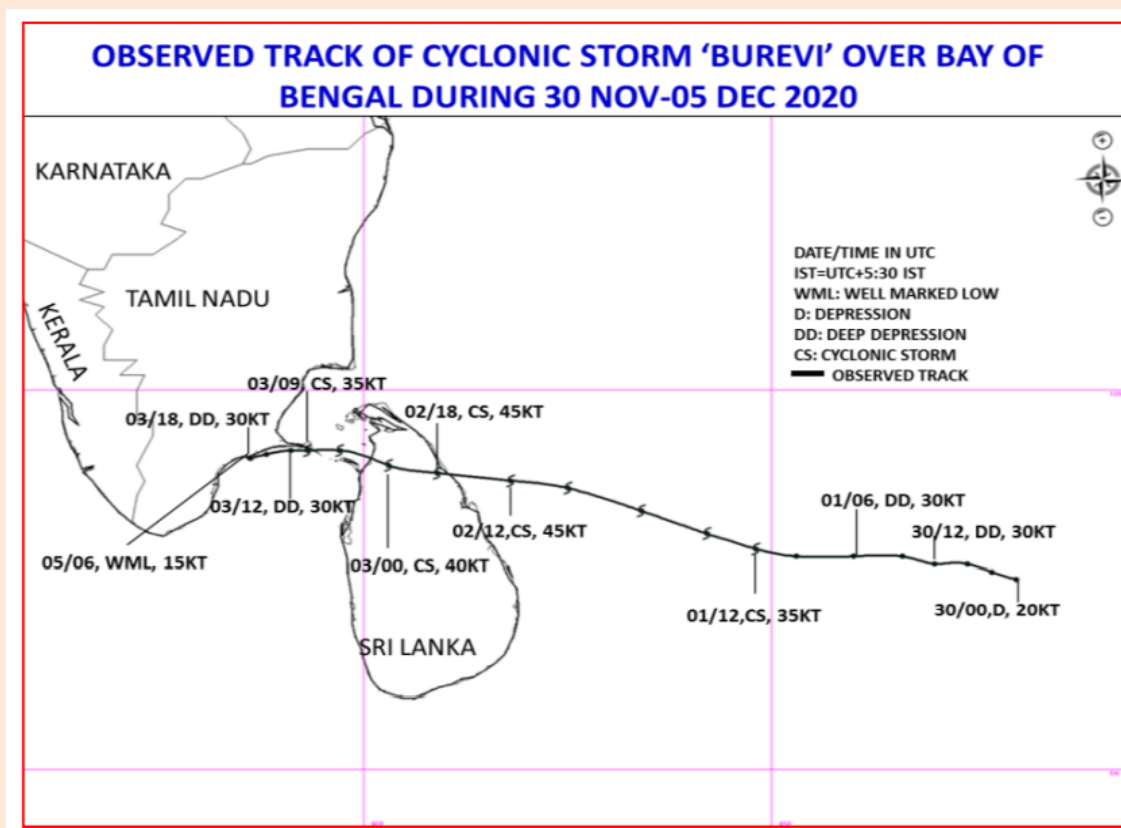
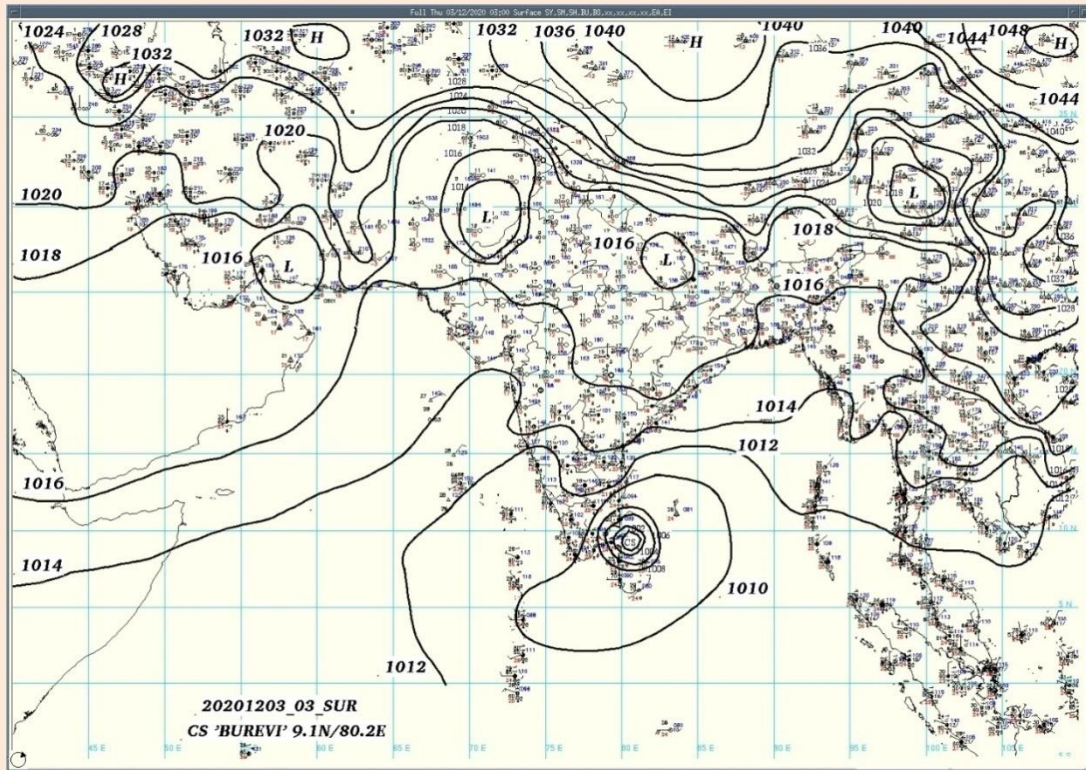
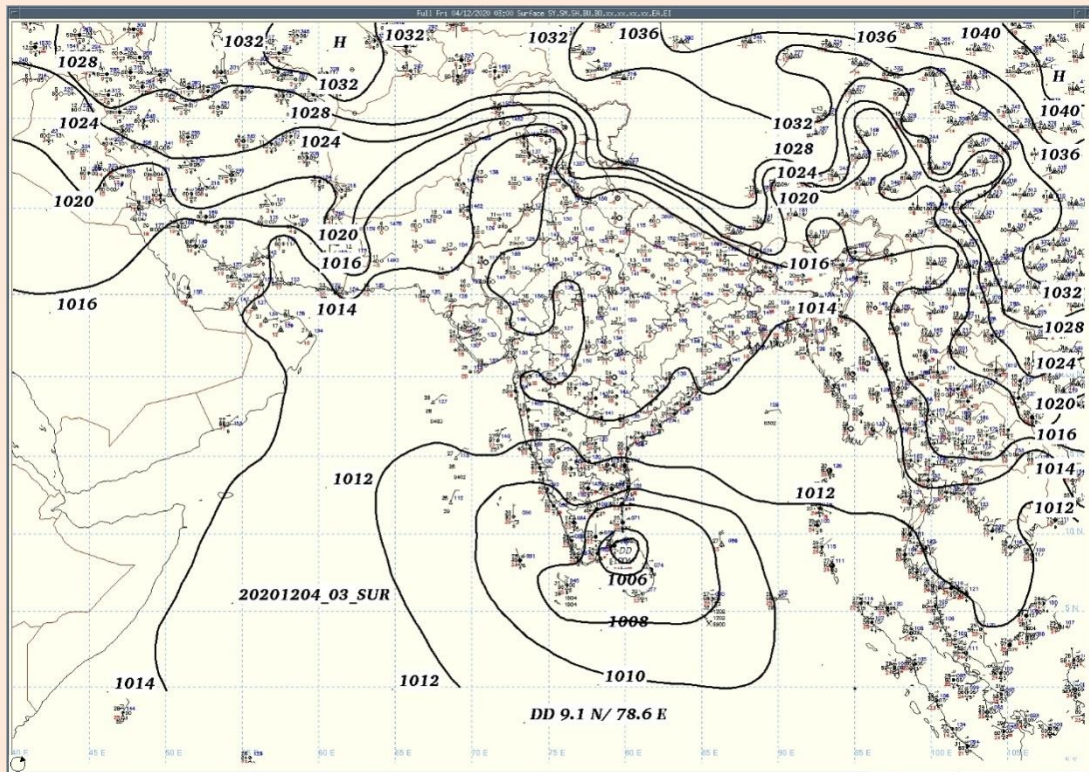


Fig.2d(i): Track of the CS *BUREVI* during 30 Nov - 05 Dec 2020



(a)



(b)

Fig.2d(ii) Surface isobaric analysis indicating the location and intensity of the system as on (a) 03 Dec 2020 / 0830 IST & (b) 04 Dec 2020 / 0830 IST.

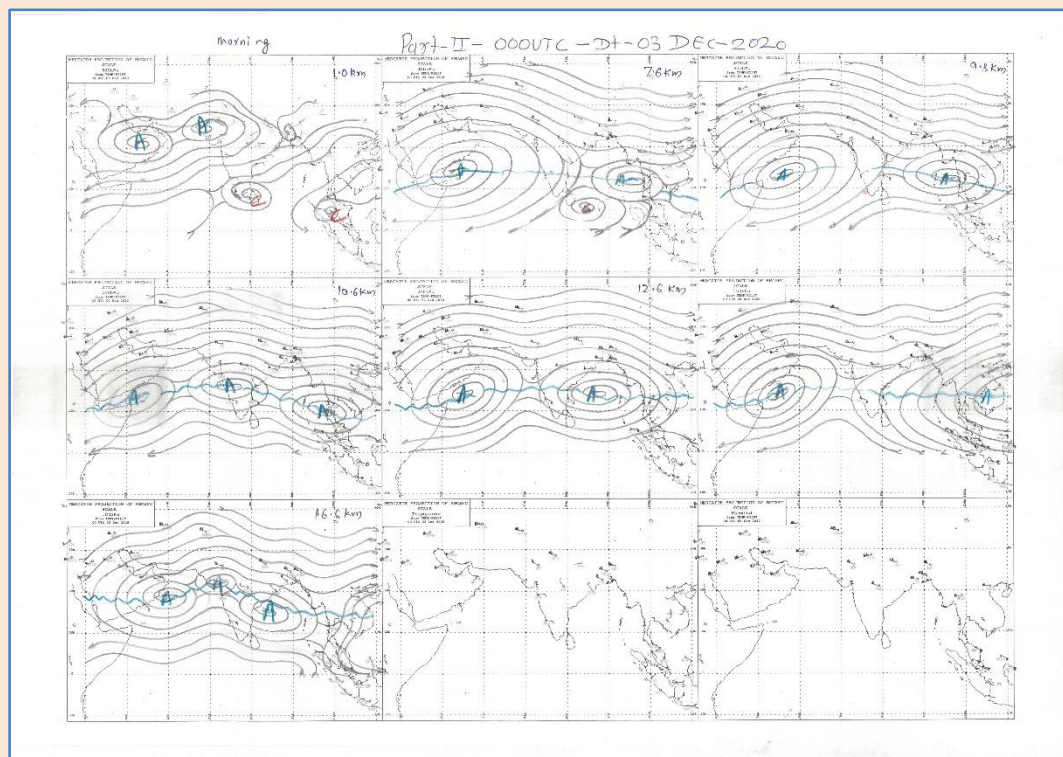
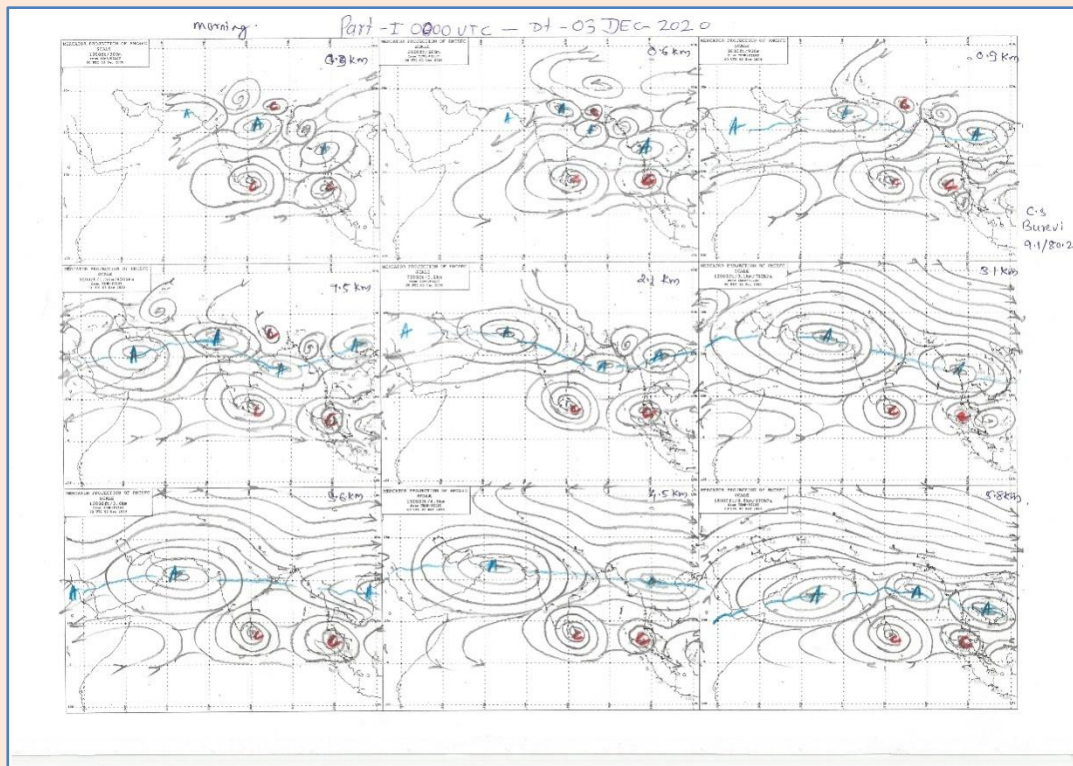


Fig.2d(ii)-c Upper air streamline analysis indicating the cyclonic circulation associated with the system as on 03 Dec 2020 / 0530 IST.

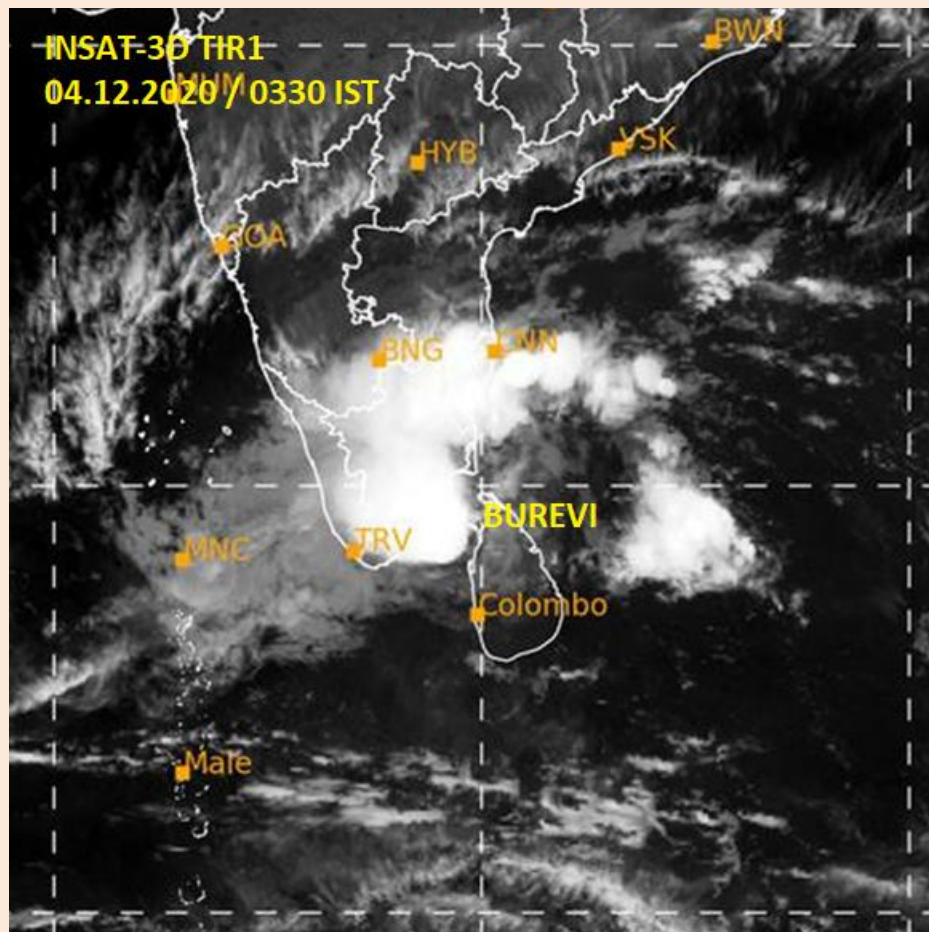


Fig.2d(iii): INSAT-3D imagery of CS BUREVI as on 04th December 2020 / 0330 IST

The system was interacting with land on 02nd and 03rd December prior to its emergence into the Gulf of Mannar and moving across Pamban area on 03rd noon. Further, outflow from an anticyclone located to the northeast of the system centre at 500 hPa level [Fig.2d(iv)] enhanced the convergence to the north of the system centre. As such, extensive rainfall activity was reported along the coastal districts during 03rd-05th December. Heavy to very heavy rain at a few places with isolated extremely heavy falls occurred in Nagapattinam, Cuddalore, Villupuram, Tiruvarur, Thanjavur and Ramanathapuram districts with Vedaranyam recording 20 cm of rain as on 24-hr ending 0830 IST of 03rd December and the delta and adjoining districts recording extremely heavy rain as on 24-hr ending 0830 IST of 04th December 2020 [Kollidam (Nagapattinam district): 36 cm, Chidambaram (Cuddalore district): 34 cm, Lalpet ARG (Cuddalore district): 28 cm, Parangipettai (Cuddalore district): 26 cm, Manalmedu (Nagapattinam district), K.m.koil (Cuddalore district), Kurinjipadi (Cuddalore district): 25 cm each, Thiruthuraipoondi (Tiruvarur district): 22 cm, Sirkali (Nagapattinam district), Kodavasal (Tiruvarur district), Sethiyathope (Cuddalore district): 21 cm each]. Rameswaram (Ramanathapuram district) reported 20 cm of rain on the same day. Subsequently on 05th

December also heavy to very heavy rainfall occurred in the coastal districts. IMD gridded rainfall and GPM sat+gauge merged rainfall as on 24-hr ending 0830 IST of 03rd and 04th December 2020 depicting the regions of heavy rainfall are presented in Fig.2d(v). The rainfall distribution over the TN subdivision on 04th and 05th December 2020 is shown in Fig.2d(vi). Subsequently under the influence of the remnant of the system, rainfall activity continued till 09th December 2020.

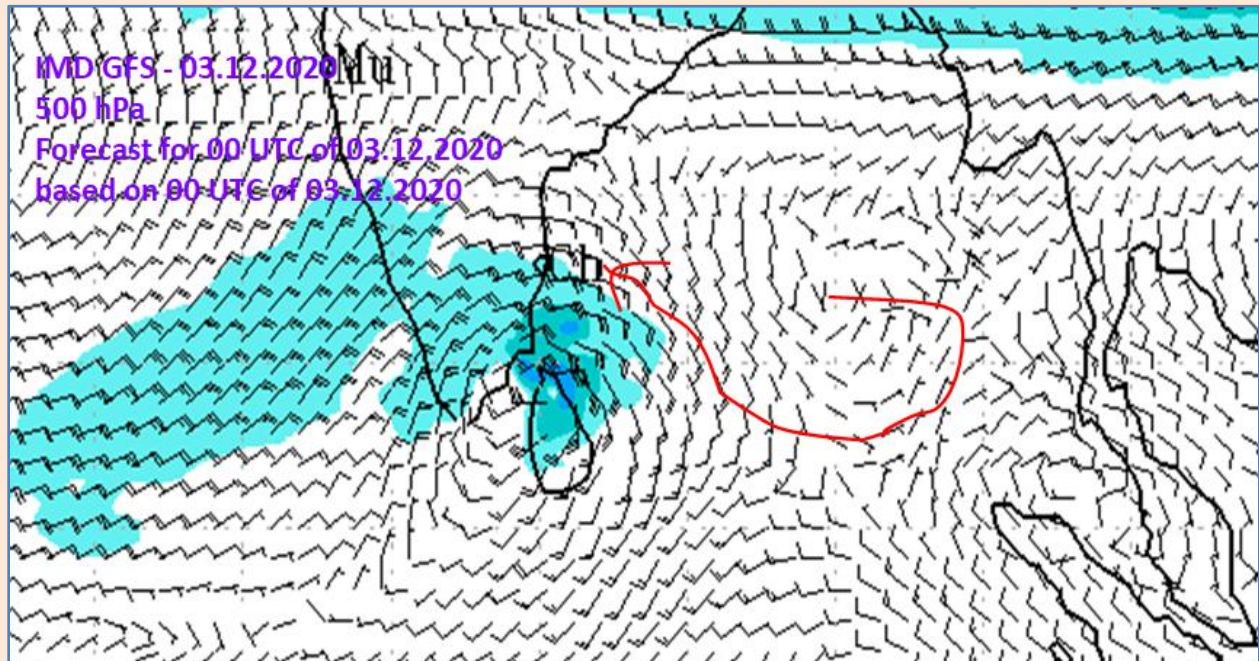


Fig.2d(iv): IMD-GFS, 500 hPa wind forecast for 0000 UTC of 03.12.2020 based on 0000 UTC of 03.12.2020

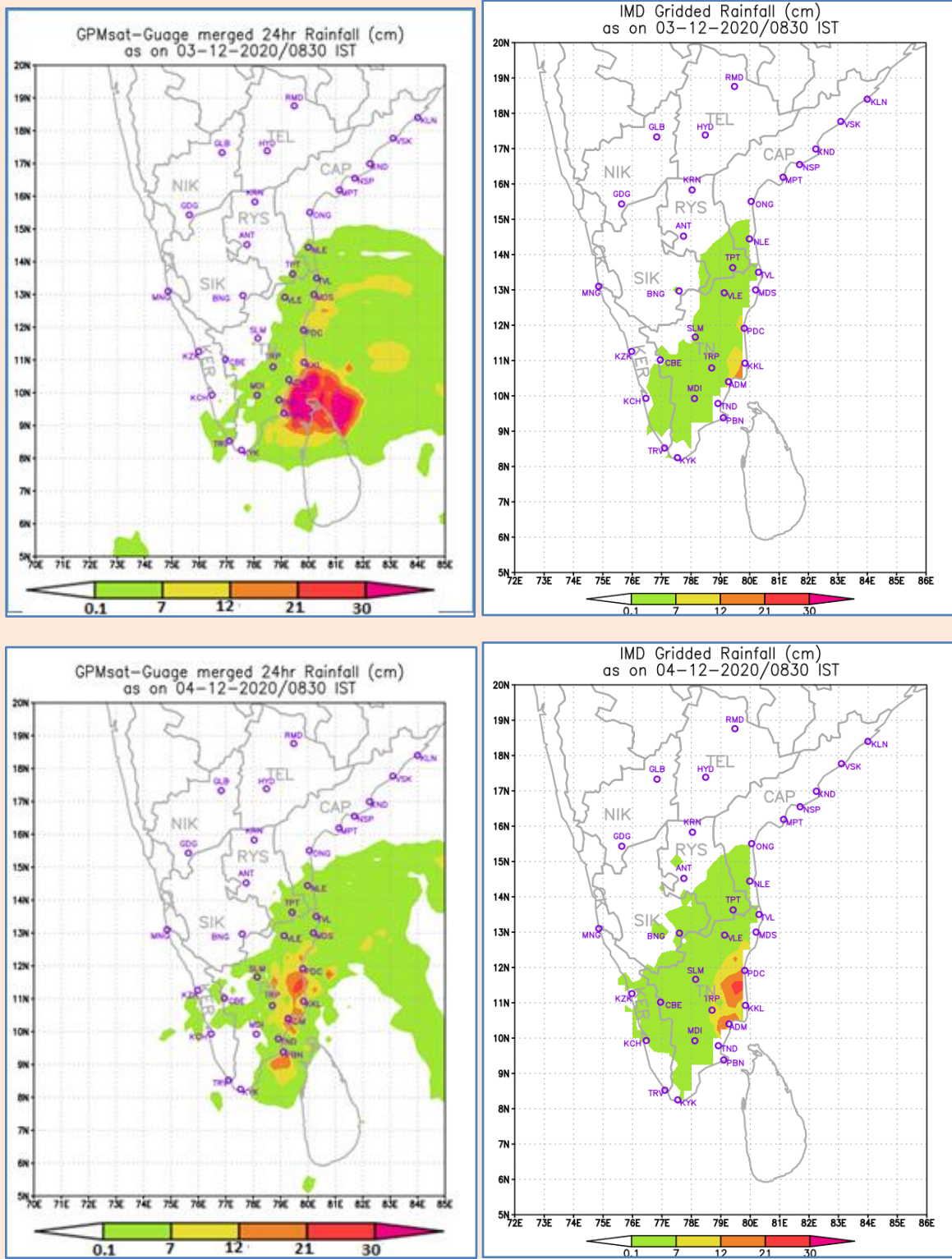


Fig.2d(v): IMD gridded rainfall and GPM sat+gauge merged rainfall as on 24-hr ending 0830 IST of 03 and 04 December 2020

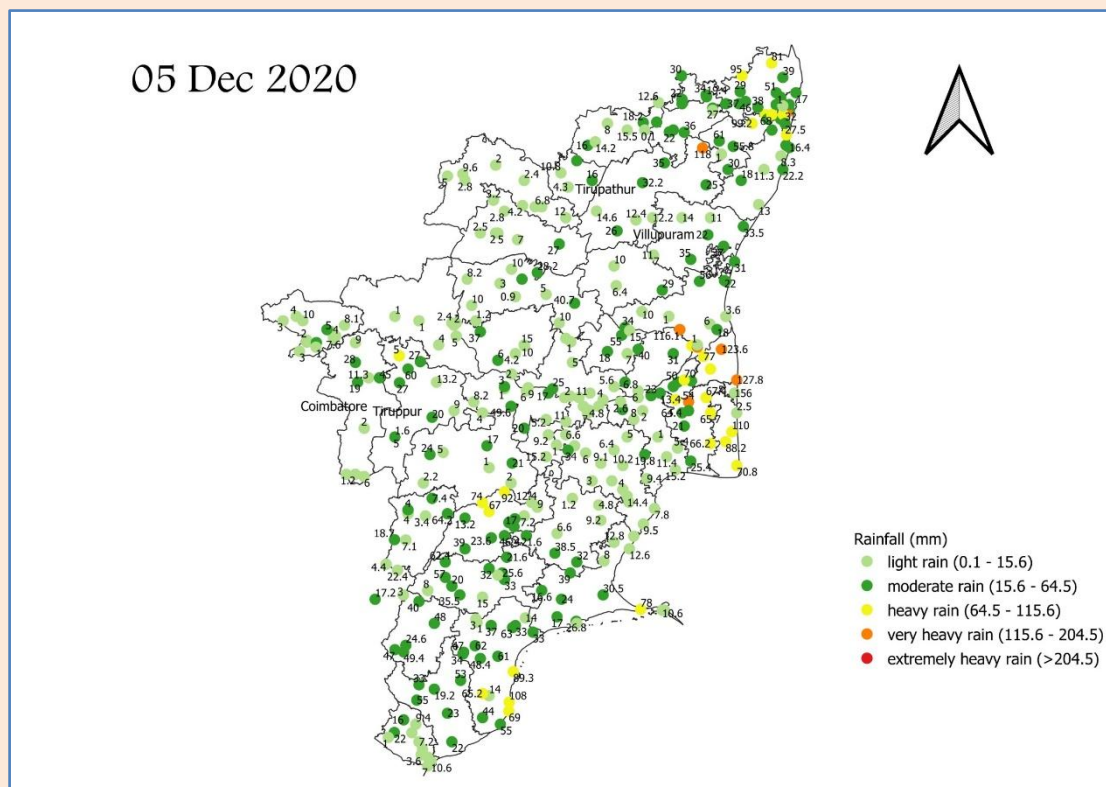
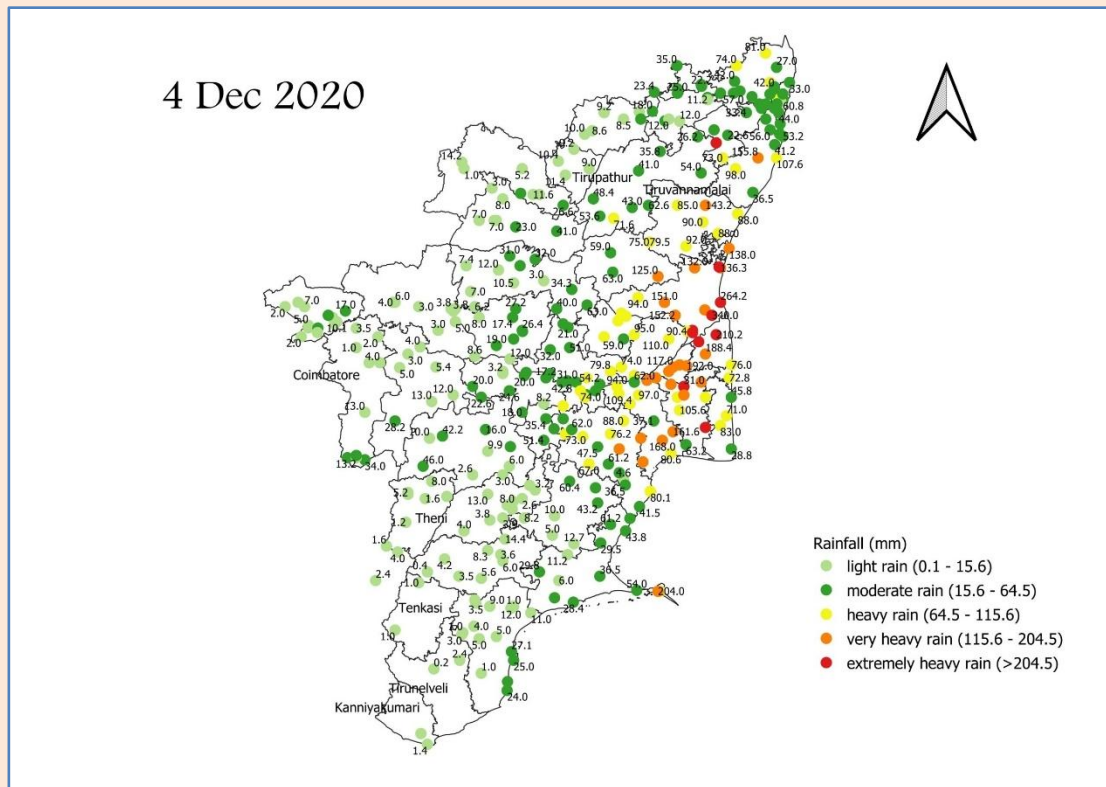


Fig.2d(vi): Gauge rainfall distribution over TN as on 24-hr ending 0830 IST of 04 a& 05 Dec 2020

The rainfall during the period 02nd-09th December 2020 accounted for about 28% of seasonal normal rainfall over the TN subdivision. More than 50% of seasonal normal rainfall of Cuddalore, Villupuram, Nagapattinam, Karaikal, Thiruvapur, Thanjavur, & Perambalur districts was realized during this period [Fig.2d(vii)]. Almost all the districts in the subdivision (excepting Kanyakumari) received more than 10% of seasonal normal rainfall during this period. The system caused extensive inland flooding, landslides in hilly regions and extensive damages to crops. A few photographs depicting the damages caused are presented in Fig.2d(viii).

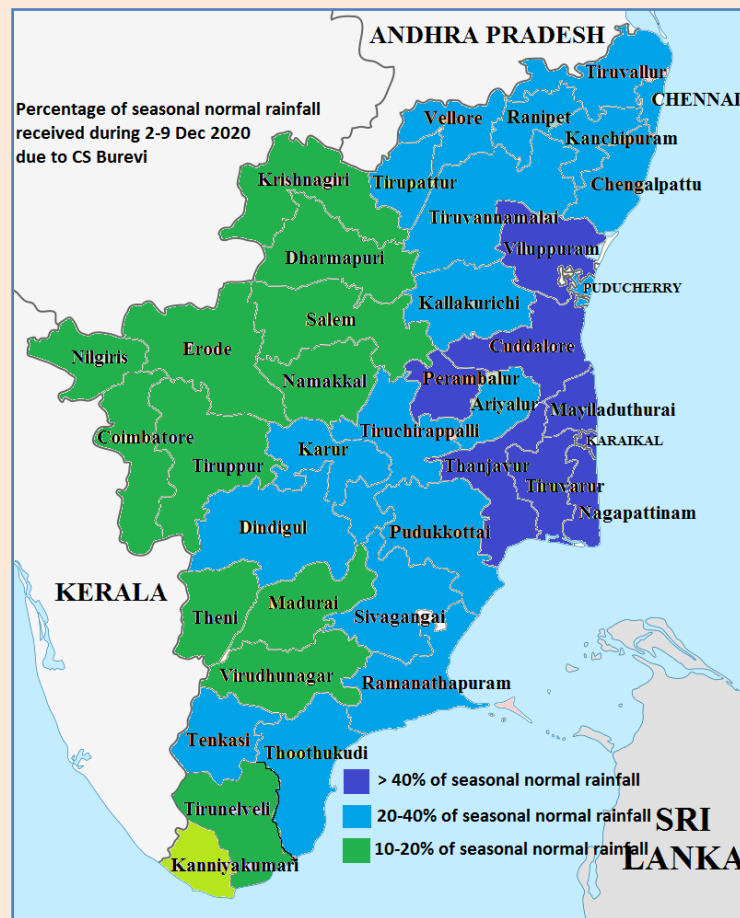


Fig.2d(vii): Percentage of seasonal normal rainfall received during 02-09 Dec 2020 in association with the passage of CS BUREVI.



Fig.2d(viii): Damages due to CS BUREVI

3.2 Other synoptic scale weather systems

Aside from the cyclones and depressions that affected the performance of NEM 2020, other major synoptic scale weather systems that influenced the NEM 2020 were the transient easterly wave troughs across the peninsular India. During the period October-December 2020, frequent easterly wave troughs that moved across peninsular India from east to west contributed significantly to the NEM rainfall during the season. Analysis of Hovmoller plots of 6-hrly meridional wind along 10°N latitude at 700 hPa for the period 1st October – 31st December 2020 indicated four easterly wave troughs that moved across the peninsular India – (i) 8th-12th November 2020, (ii) 12th-16th November 2020, (iii) 12th-16th December 2020 and (iv) 26th-30th

December 2020. Streamline analysis of 850 hPa wind depicting the trough in the easterlies, INSAT-3D infra-red imagery showing inverter V-shaped cloudiness, Hovmoller plot of 6-hrly meridional wind at 700 hPa indicating the passage of the wave trough across the east coast of peninsular India (about 80°E longitude) and 24-hr rainfall depicted by GPM sat+gauge merged rainfall associated with the passage of the above four wave troughs at representative dates and time are presented in Fig.3(a-d)(i-iv).

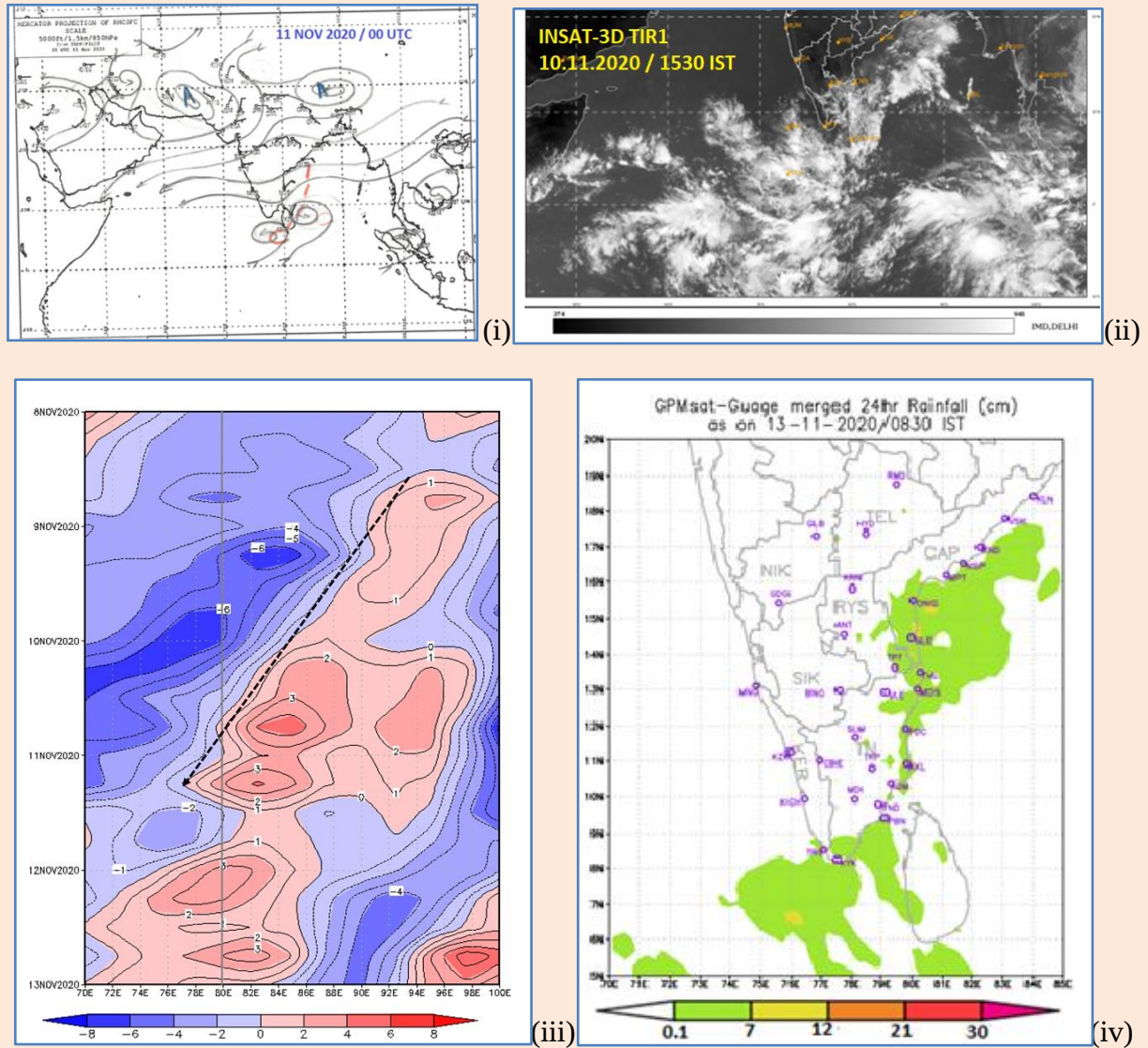
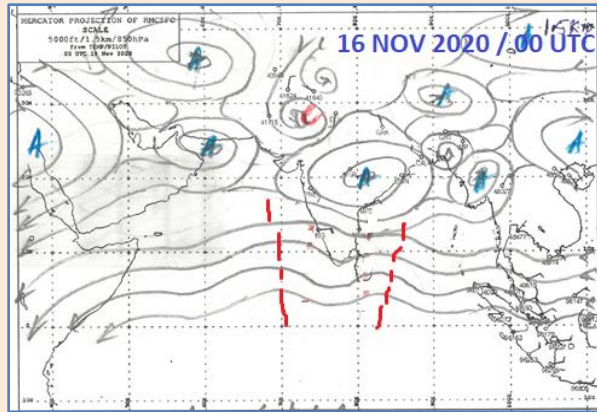
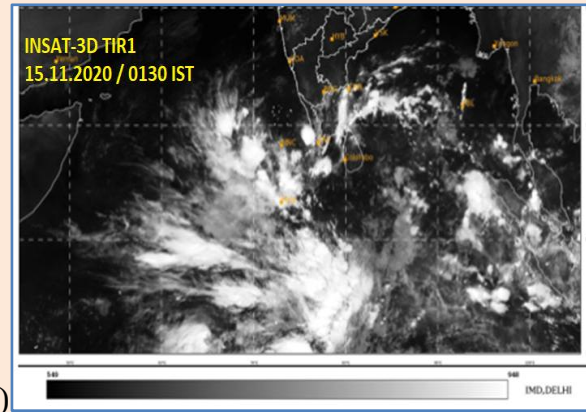


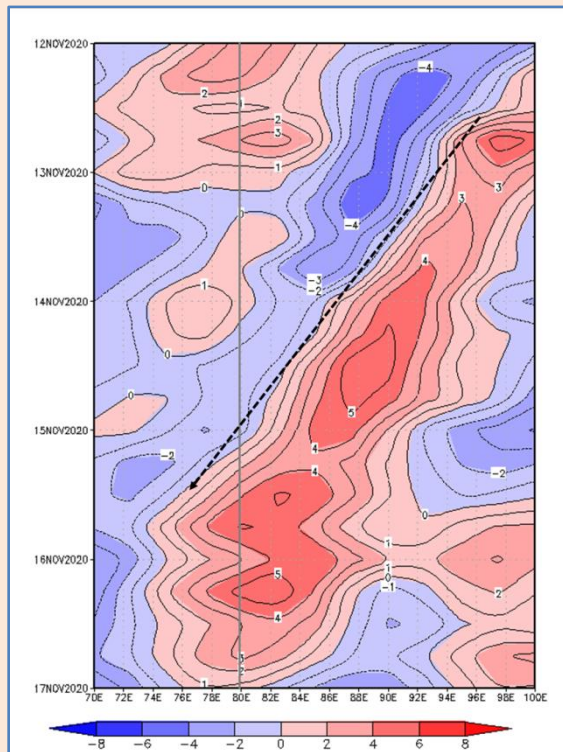
Fig. 3a: (i) Streamline analysis of 850 hPa wind as on 0530 IST of 11 Nov 2020 (ii) INSAT-3D infrared imagery as on 1530 IST of 10 Nov (iii) Hovmoller plot of 700 hPa 6-hrly meridional wind (m/s) along 10°N for the period 08-13 Nov / 0530 IST & (iv) GPM sat+gauge merged rainfall as on 24-hr ending 0830 IST of 13 Nov 2020. Arrows indicate the westward moving wave trough. Grey line indicates the 80°E longitude (along /off the coast).



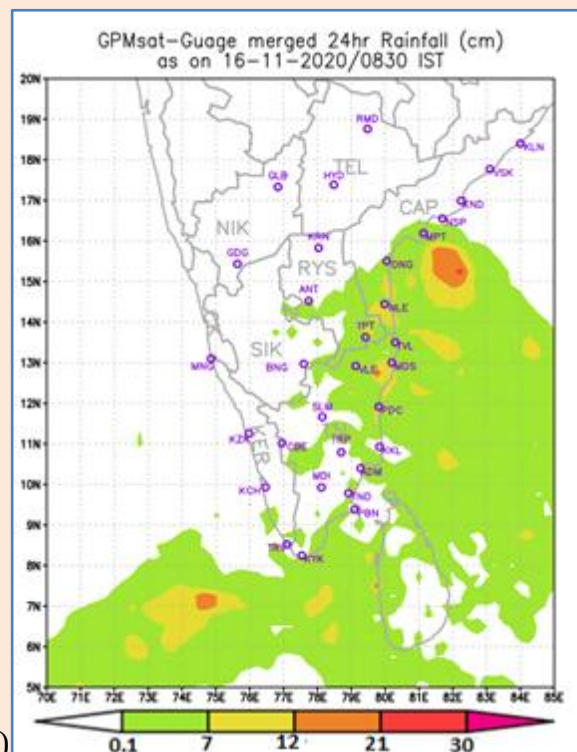
(i)



(ii)

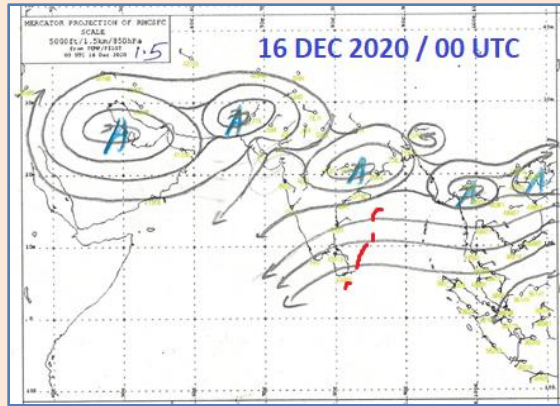


(iii)

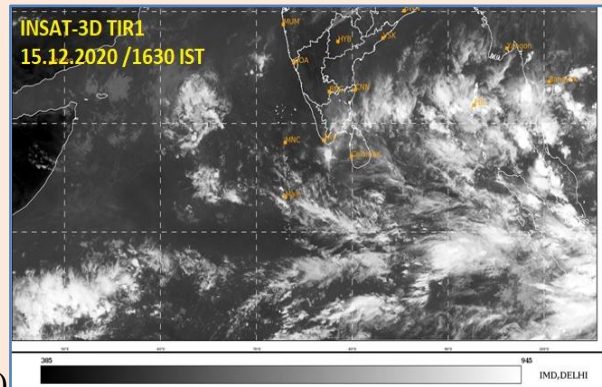


(iv)

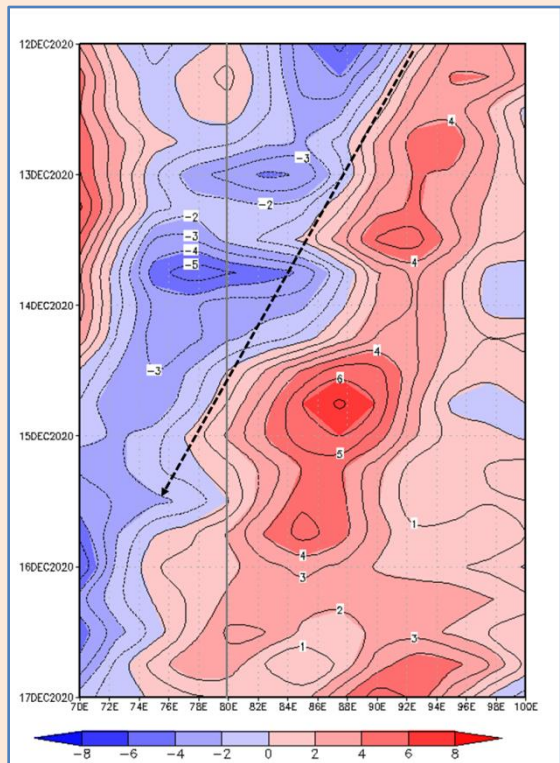
Fig. 3b: (i) Streamline analysis of 850 hPa wind as on 0530 IST of 16 Nov 2020 (ii) INSAT-3D infrared imagery as on 0130 IST of 15 Nov (iii) Hovmoller plot of 700 hPa 6-hrly meridional wind along 10°N for the period 12-17 Nov / 0530 IST& (iv) GPM sat+gauge merged rainfall as on 24-hr ending 0830 IST of 13 Nov 2020. Arrows indicate the westward moving wave trough. Grey line indicates the 80°E longitude (along /off the coast).



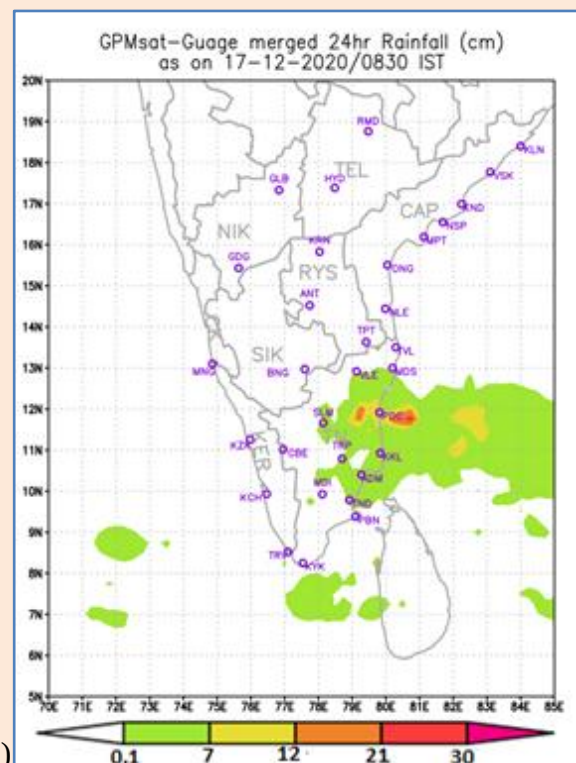
(i)



(ii)



(iii)



(iv)

Fig. 3c: (i) Streamline analysis of 850 hPa wind as on 0530 IST of 16Dec 2020 (ii) INSAT-3D infrared imagery as on 1630 IST of 15Dec (iii) Hovmoller plot of 700 hPa 6-hrly meridional wind along 10°N for the period 12-17 Dec / 0530 IST& (iv) GPM sat+gauge merged rainfall as on 24-hr ending 0830 IST of 17Dec 2020. Arrows indicate the westward moving wave trough. Grey line indicates the 80°E longitude (along /off the coast).

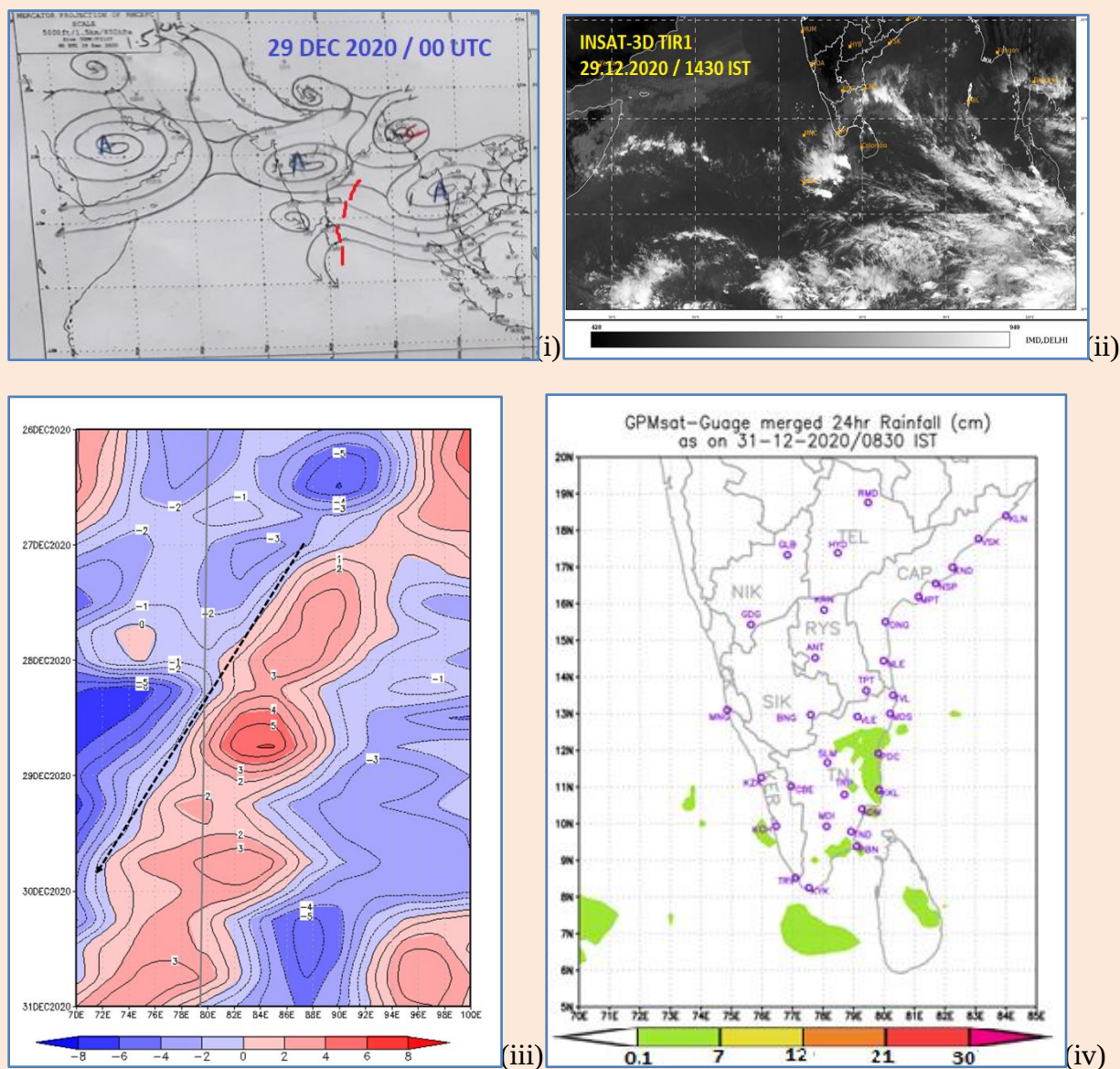


Fig. 3d: (i) Streamline analysis of 850 hPa wind as on 0530 IST of 29Dec 2020 (ii) INSAT-3D infrared imagery as on 1430 IST of 29Dec (iii) Hovmoller plot of 700 hPa 6-hrly meridional wind along 10°N for the period 26-31 Dec / 0530 IST& (iv) GPM sat+gauge merged rainfall as on 24-hr ending 0830 IST of 31 Dec 2020. Arrows indicate the westward moving wave trough. Grey line indicates the 80°E longitude (along / off the coast).

It is observed from the above analysis that two tropical cyclones and frequent easterly wave troughs that moved across Tamil Nadu contributed significantly towards NEM-2020 rainfall. In the daily rainfall plot for the TN subdivision for the period October-December 2020, various active rain spells could be identified with these synoptic scale weather systems (Fig.3e).

Subsequently too, the NEM activity extended into first half of January 2021 and cessation of NEM rains over the southern peninsular India occurred on 19th January 2021 only.

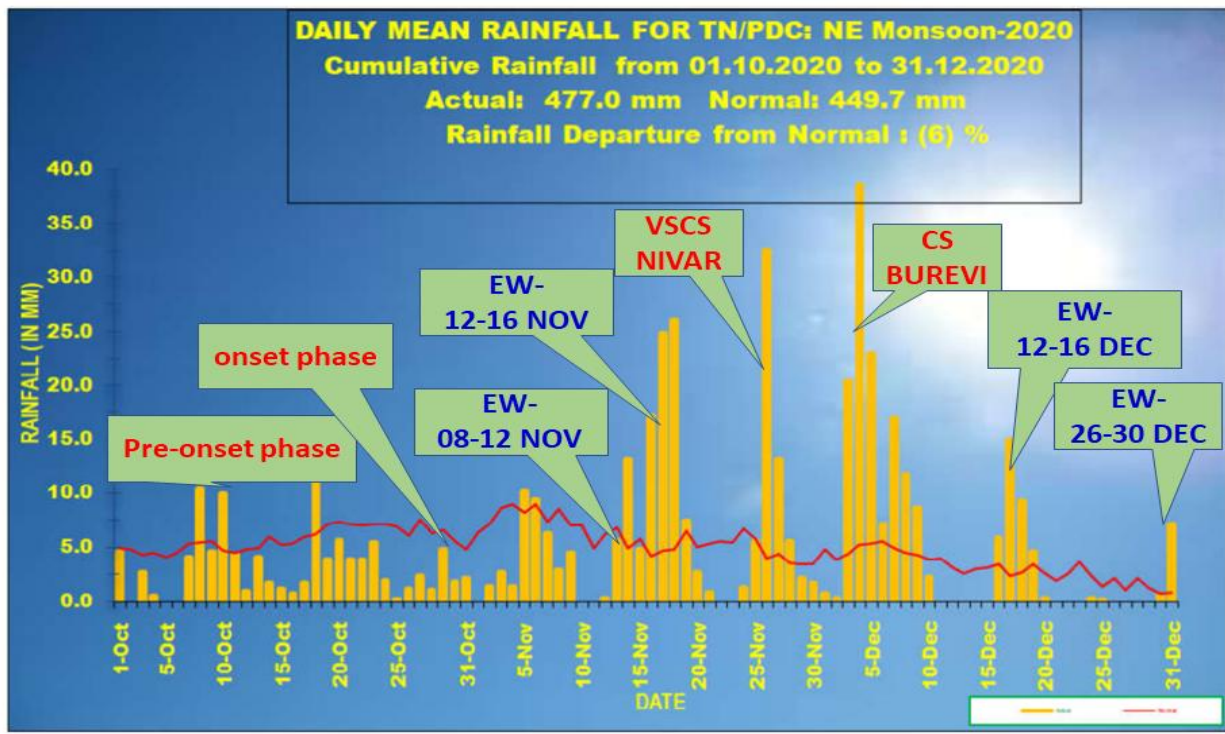


Fig.3e: Daily mean rainfall over TN subdivision during October-December 2020 and the synoptic conditions associated with the rainfall pattern.

4. Subdivisional rainfall performance during NEM 2020

4.1 Seasonal rainfall performance

During 2020, the northeast monsoon seasonal rainfall was *normal* (-19% to +19%) to *excess* (+20% to +59%) in four out of five meteorological subdivisions benefitted by the NEM i.e., TN, KER, CAP, RYS and SIK. It was *excess* over RYS (+54%) and CAP (+24%), *normal* over TN and SIK (+6%& 0% respectively) and *deficient* over KER (-26%). Fig.4 and Table-1 present the season ending (01st Oct-31st Dec) rainfall figures over these subdivisions.

4.2 Monthly, weekly and daily rainfall scenario

The intra-seasonal rainfall distribution over various sub-divisions during Oct-Dec 2020 is presented in monthly, weekly and daily scales. Month-wise rainfall statistics are presented in Table-2. Tables-3a&b depict the week by week performance (weekly & cumulative), Table-4a&b present the daily rainfall scenario in terms of spatial rainfall distribution (*Widespread*:WD, *Fairly widespread*: FWD, *Scattered*: SCT, *Isolated*: ISOL and DRY), frequency of active and vigorous monsoon days and frequency of heavy rainfall days (**Heavy** rainfall $\geq 7\text{cm/day}$; **Very Heavy** rainfall $\geq 12\text{cm/day}$; **Extremely Heavy** rainfall $\geq 21\text{ cm/day}$).

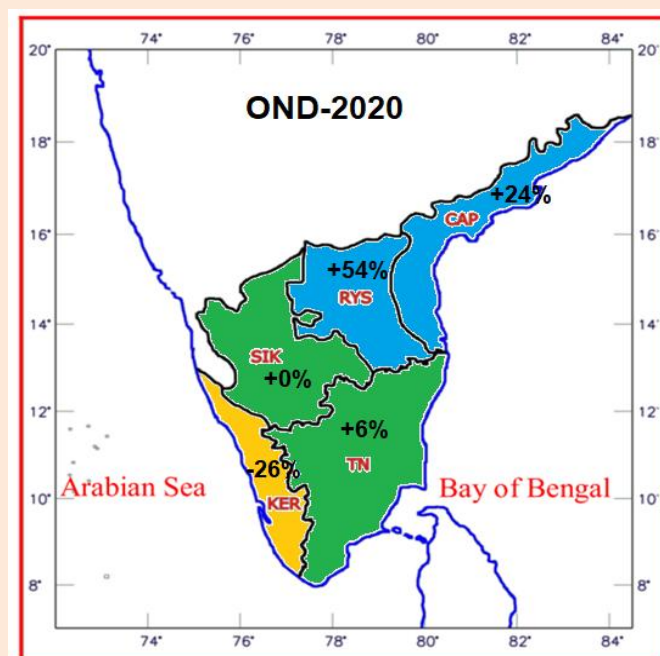


Fig.4: Seasonal rainfall performance of NEM 2020 over the five meteorological subdivisions benefitted by the NEM

Table-1: Sub-divisional seasonal rainfall during October-December 2020

Subdivision	01 st October – 31 st December 2020		
	Actual (mm)	Normal (mm)	PDN (%)
TAMIL NADU, PUDUCHERRY & KARALKAL	477.0	449.6	+6%
KERALA& MAHE	365.2	491.6	-26%
COASTAL ANDHRA PRADESH& YANAM	419.3	338.1	+24%
RAYALASEEMA	343.2	223.2	+54%
SOUTH INTERIOR KARNATAKA	203.1	204.1	0%

PDN: Percentage Departure from Normal

Legend:

<i>Largely Deficient</i>	<i>Deficient</i>	<i>Normal</i>	<i>Excess</i>	<i>Large Excess</i>
$\leq -60\%$	-20% to -59%	-19% to +19%	+20% to +59%	$\geq +60\%$

Table-2: Sub-divisional monthly rainfall during NEM 2020

Sub-division	OCT			NOV			DEC		
	Actual (mm)	Normal (mm)	PDN (%)	Actual (mm)	Normal (mm)	PDN (%)	Actual (mm)	Normal (mm)	PDN (%)
TN	101.0	177.6	-43	203.3	179.5	+13	172.8	92.6	+87
KER	222.8	303.4	-27	99.3	153.4	-35	43.1	34.8	+24
CAP	212.4	191.3	+11	181.0	117.3	+54	25.9	29.5	-12
RYS	141.1	129.8	+9	155.7	70.2	+122	46.5	23.3	+99
SIK	149.5	141.6	+6	37.9	44.9	-12	15.6	11.9	+31

(TN, KER, CAP, RYS, SIK and Legend: same as Table-1)

Table-3a: Week by week rainfall departures (%) during NEM 2020

Subdivision	07.10.20	14.10.20	21.10.20	28.10.20	04.11.20	11.11.20	18.11.20	25.11.20	02.12.20	09.12.20	16.12.20	23.12.20	30.12.20
TN	-64	-1	-34	-68	-70	-36	+146	-55	+119	+291	-65	+53	-91
KER	-85	+87	-30	-73	-75	-49	+37	-79	+16	+84	+27	-40	-27
CAP	-45	+245	+21	-92	-91	-56	+68	-82	+701	+121	-99	-96	-100
RYS	-26	+114	+22	-16	-94	-66	+118	-87	+1107	+332	-91	-94	-100

Table-3b: Weekly cumulative rainfall departures (%) during NEM 2020

Subdivision	07.10.20	14.10.20	21.10.20	28.10.20	04.11.20	11.11.20	18.11.20	25.11.20	02.12.20	09.12.20	16.12.20	23.12.20	30.12.20
TN	-64	-31	-32	-43	-49	-46	-22	-26	-16	9	5	7	5
KER	-85	4	-7	-22	-32	-34	-28	-31	-30	-26	-26	-26	-26
CAP	-45	77	57	22	-2	-8	-1	-6	27	30	26	25	24
RYS	-26	30	28	18	-2	-10	3	-2	47	62	58	56	54

(TN, KER, CAP, RYS, SIK & Legend: same as Table-1)

TN: Tamil Nadu & Puducherry;

KER: Kerala;

CAP: Coastal Andhra Pradesh;

RYS: Rayalaseema;

SIK: South Interior Karnataka

In the monthly scale, in October 2020, due to delayed onset of NEM on 28th, rainfall activity over the TN subdivision was weak. By the end of October, TN and KER came under *deficient* category (-43% and -27% respectively). However, under extended SWM conditions, the other three subdivisions – CAP, RYS & SIK received normal rainfall of +6% to +11%. In

November, under the influence of the passage of VSCS *Nivar* and two easterly wave troughs across the peninsular India, four subdivisions – TN, CAP, RYS & SIK received above normal rainfall with RYS recording *large excess* rainfall of +122% followed by CAP with *excess* rainfall of +54%. TN & SIK received *normal* rainfall (+13% and -12%). However, KER continued to fall under *deficient* category (-35%). However, in December, under the influence of CS *Burevi* and easterly wave activity, all the five subdivisions received above normal rainfall with RYS and TN recording *large excess* rainfall of +99% and +87%. KER and SIK came under *excess* category with +24% and +31% respectively and CAP under *normal* category at -12%.

The weekly scenario (tables 3a 3b) indicates that prior to the onset of NEM, during the first four weeks of October 2020, excepting TN, the other subdivisions benefitted from the extended SWM. Even after the onset on 28th October, for the next two weeks, there was generally subdued activity only. Subsequently, during the week 11th-18th November, under the influence of easterly wave activity, there was *excess* to *large excess* rainfall over the region. TN & RYS received +146% and +118% of rainfall during this week taking their seasonal rainfall figures from -46% to -22% and -10% to +3% respectively. Again, after a week of subdued activity, under the influence of VSCS *Nivar* and CS *Burevi*, there was intense rainfall activity for two weeks from 26th November to 9th December. During these two weeks, RYS received +1107% and 332% of normal taking the seasonal figures from -2% to +62%, CAP: +701% and +121% (seasonal figures improved from -6% to +30%) and TN: +119% and +291% (taking seasonal rainfall performance from -26% to +9%). Kerala received +84% during the week ending 09th December. Subsequently, rainfall activity decreased gradually till 30th December.

In the daily scale, TN and KER experienced *isolated* to *scattered* rainfall activity on about 76% and 66% of the days respectively and *fairly widespread* to *widespread* rainfall on about 21% to 22% of the days during the season (Table-4a). CAP, RYS and SIK experienced *scattered* to *widespread* rainfall on about 29% to 35% of the days during the season and on about 65-71% of the days, *dry* or *isolated* rainfall conditions prevailed over these subdivisions.

4.3 Monsoon activity and Heavy rainfall occurrences

There were 16-17 days of *active* to *vigorous* monsoon conditions over TN and RYS subdivisions and 8-10 days of *active* to *vigorous* monsoon conditions over CAP, KER and SIK (Table-4b). Regarding heavy rainfall occurrences (≥ 7 cm/day), TN experienced isolated *heavy* rainfall activity on 50 days during the season, out of which, 22 days were with isolated *very heavy* falls. There were four days of isolated *extremely heavy* rainfall over the TN subdivision – On 18th November, Kayalpattinam (Toothukudi district) recorded 21 cm of rain under the influence of passage of an easterly wave trough; On 26th and 27th November the following *extremely heavy* rainfall occurrences were reported due to the passage of VSCS *Nivar*- 26th November: Puducherry – 30 cm, Cuddalore and Villupuram – 28 cm each, Chennai-Mylapore (DGP office) – 26 cm, Sholinganallur- 22 cm; 27th November: Sholingur (Ranipet district) – 23 cm and on 04th December under the influence of CS *Burevi*, Kollidam (Nagapattinam district)

reported 36 cm, Chidambaram (Cuddalore district) – 34 cm, Lalpet ARG, Parangipettai, Kattumannarkoil, Kurinjipadi and Sethiyathope (all Cuddalore district) and Sirkali, Manalmedu (Nagapattinam district), Thiruthuraipoondi and Kodavasal (Tiruvarur district)– 21-28 cm.

Table-4a: Frequency of various categories of spatial rainfall distribution during October to December 2020

Subdivision	No. of days				
	WD	FWD	SCT	ISOL	DRY
TN	10	9	24	46	3
KER	13	7	17	44	11
CAP	8	6	13	42	23
RYS	6	10	12	33	31
SIK	5	10	17	29	31

WD: Widespread

(76-100% of stations reporting rainfall)

SCT: Scattered

(26-50% of stations reporting rainfall)

DRY: No rain

FWD : Fairly widespread

(51-75% of stations reporting rainfall)

ISOL: Isolated

(≤25% of stations reporting rainfall)

Table-4b: Frequencies of active and vigorous monsoon days and heavy rainfall days during October – December 2020

Subdivision	No. of days				
	Activity		Heavy Rainfall		
	Vigorous	Active	Extremely Heavy	Very Heavy	Heavy
TN	8	9	4	22	50
KER	2	6	0	2	15
CAP	6	4	3	4	23
RYS	7	9	2	4	12
SIK	2	7	1	14	23

Active: Fairly widespread to widespread sub-divisional rainfall with rainfall more than 1½ to 4 times the normal with at least two stations reporting more than or equal to 5 cm in coastal Tamil Nadu, south coastal Andhra Pradesh and 3 cm elsewhere in the NEM region.

Vigorous: Fairly widespread to widespread sub-divisional rainfall with rainfall more 4 times the normal with at least two stations reporting more than or equal to 5 cm in coastal Tamil Nadu, south coastal Andhra Pradesh and 3 cm elsewhere in the NEM region.

Heavy:rainfall ≥ 7cm/day;

Very Heavy: rainfall ≥ 12cm/day; **Extremely Heavy:** rainfall ≥21 cm/day

Table-4c: District-wise list of very to extremely heavy rainfall occurrences over the various subdivisions during October-December 2020

District	Date, Station and 24-hr accumulated rainfall (in cm) (ending 0830 IST of the specified date)
Tamil Nadu, Puducherry & Karaikal	
Cuddalore	Oct ^{08th} : Kuppunatham-14; 10 th :Vepur-13 Nov ^{26th} :Cuddalore-28, Parangipettai-18, Bhuvanagiri-14, Kurinjipadi-13, Chidambaram Aws-13, Chidambaram-13 Dec ^{04th} : Chidambaram-34, Lalpet ARG-28, Parangipettai-26, K.m.koil-25, Kurinjipadi-25, Sethiyathope-21, Bhuvanagiri-19, Srimushnam-15, Vridhachalam-15, Cuddalore-14, Panruti-13; 05 th : Kothavacheery-19, Bhuvanagiri-15, Sethiyathope-14, Srimushnam-12
Tiruvannamalai	Oct ^{09th} : Polur-12 Nov ^{26th} : Keelpennathur-12 Dec ^{04th} : Vembakkam-12
Pudukkottai	Oct ^{18th} : Perumgalur-13 Dec ^{04th} : Karambakudi-17, Alangudi-12
Tiruvallur	Oct ^{23rd} :Pallipattu-17, R.k.pet-13; 29 th :Red Hills-13 Nov ^{25th} : Puzhal Arg-12, Chembarambakkam ARG-12; 26 th : Tamaraipakkam-19, Pallipattu-17, Cholavaram-16, Poonamallee-15, Ambathur-15, Tiruvallur -15, Gummidipoondi-15, Chembarabakkam-14, Red Hills-13, Tiruttani-13, Poondi-12, Koratur-12; 27 th : R.K.Pet-13
Chennai	Oct ^{29th} : DGP Office-18, Anna University ARG-14, Chennai(N)-13 Nov ^{25th} : Chennai(N)-16, Anna Uty-15, Chennai AP-15, Sholinganallur-15, Taramani ARG -14, Anna University-14, DGP Office-14, Mgr Nagar-14, Alandur-12; 26 th : DGP Office-26, Sholinganallur-22, Anna University-14, Mgr Nagar-13, Alandur-13 Dec ^{05th} : DGP Office-12
Tiruppur	Nov ^{05th} :Dharapuram-17, Mulanur-13
Virudhunagar	Nov ^{05th} :Pilavakkal-16
Dindigul	Nov ^{05th} :Odanchatram-12
Nilgiris	Nov ^{06th} :Kothagiri-12
Kancheepuram	Nov ^{16th} : Sriperumbudur-18, Kancheepuram-16; 26 th : Kancheepuram-13
Villupuram	Nov ^{16th} : Marakkanam-12; 26 th : Vilupuram-28, Gingee-15, Tindivanam-14, Vanur-14, Marakkanam-13 Dec ^{04th} : Tindivanam-14; 17 th : BASL Manampoondi-17, RSCL-3 Anandhapuram-16, RSCL-2 Kedar-16, BASL Mugaiyur-16, Tirukoilur-16, Mylam AWS-13
Toothukudi	Nov ^{17th} :Toothukudi-17, Toothukudi port AWS-15; 18 th : Kayalpattinam-21; 19 th :Ottapidaram-12 Dec ^{07th} : Maniyachi-16, Vaippar-12
Tirunelveli	Nov ^{17th} : Papanasam-14; 18 th :Papanasam-12
Ramanathapuram	Nov ^{18th} : Paramakudi-13 Dec ^{03rd} : Rameswaram-12; 04 th : Rameswaram-20
Chengalpattu	Nov ^{25th} : Mahabalipuram-12, Hindusthan University-12; 26 th : Mahabalipuram-15, Maduranthagam-14, Chengalpattu-13, Tambaram-12 Dec ^{04th} : Thirukalukundram-17

Puducherry	Nov ^{26th} : Pondicherry-30 Dec ^{04th} : Pondicherry-14, 17 th : Pondicherry-15
Nagapattinam	Nov ^{26th} : Kollidam-14, Sirkali-12 Dec ^{03rd} : Vedaranyam-20, Thalaigayner-15, Tirupoondi-15, Nagapattinam-14, Mayiladuthurai-12; 04 th : Kollidam-36, Manalmedu-25, Sirkali-21, Mayiladuthurai-19; 05 th : Nagapattinam-16, Tarangambadi-13, Sirkali-12
Kallakurichi	Nov ^{26th} : Ulundurpet-12 Dec ^{04th} : Ulundurpet-13; 17 th : Tirukoilur-16, Ulundurpet-12
Tirupathur	Nov ^{26th} : Vadapudupattu-12; 27 th : Vadapudupattu-16, Ambur-13, Alangayam-12
Ranipet	Nov ^{27th} : Sholingur-23
Vellore	Nov ^{27th} : Ponnai Dam-14, Vellore-14, Ammundi-14, Katpadi-12
Karaikal	Dec ^{03rd} : Karaikal-16; 05 th : Karaikal-16
Tiruvarur	Dec ^{03rd} : Thiruthuraipoondi-13, 04 th : Thiruthuraipoondi-22, Kodavasal-21, Nannilam-14, Valangaiman-13, Pandavaiyar Head-12; 05 th : Kodavasal-15
Thanjavur	Dec ^{04th} : Peravurani-19, Manjalaru-19, Pattukottai-17, Madukkur-16, Thanjai Papanasam-14, Thiruvaidaimaruthur-14, Kumbakonam-13, Ayyampettai-13, Aduthurai AWS-12
Kerala & Mahe	
Alappuzha	Oct ^{09th} : Chengannur-12
Ernakulam	Nov ^{18th} : Aluva-12
Coastal Andhra Pradesh & Yanam	
Vishakhapatnam	Oct ^{12th} : Bheemunipatnam-17, Vishakhapatnam-15, Vishakhapatnam AP-14; 13 th : Bheemunipatnam-16, Yelamanchili-14
East Godavari	Oct ^{12th} : Kakinada-14, Peddapuram-14; 13 th : Amlapuram-19, Kakinada-12, Prathipadu-12 Nov ^{27th} : Amlapuram-15, Kakinada-12
Yanam	Oct ^{13th} : Yanam-25 Nov ^{27th} : Yanam-14
West Godavari	Oct ^{13th} : Tanuku-19, Tadepalligudem-18, Chintalapudi-13, Narsapuram-12, Koyyalagudem-12, Palakoderu-12, Bheemavaram-12 Nov ^{27th} : Palakoderu-12
Krishna	Oct ^{13th} : Nuzvid-19, Vijayawada Ap-16, Kaikalur-15, Tiruvuru-15, Gudivada-13 Nov ^{27th} : Avnigada-15
Srikakulam	Oct ^{13th} : Palasa-15, Ichchapuram-15, Sompeta-13, Mandasa-13
Nellore	Nov ^{26th} : Venkatagiri-24, Gudur-19, Rapur-16, Atmakur-15, Sullurpetta-15, Nellore-14, Kavali-14; 27 th : Kavali-27, Udaygiri-17, Vinjamur-17, Atmakur-16
Prakasam	Nov ^{27th} : Ongole-15, Marripudi-14, Podili-14, Veligandla-14, Kandukur-14
Rayalaseema	
Cuddapah	Oct ^{11th} : Chinnamandem-13 Nov ^{26th} : Kodur-25, Sambepalle-14, Rajampet-13; 27 th : Sambepalle-20, Royachoti-18, Chinnamandem-18, Pullampeta-16, Chapad-15, Proddutur-15, Utukuru(a)-14, Vempalle-14, Kamalapuram-14, Atlur-13, Cuddapah-12
Chittoor	Oct ^{11th} : Pakala-12 Nov ^{16th} : Tirupati Aero-15; 26 th : Satyavedu-14, Nagari-13, Tirupati Aero-13, Thottambedu-12, V-12; 27 th : Gurramkonda-21, Madanapalle-18, Kalakada-18, Punganur-17, Thambalapalle-16,

	Palamaner-16, Chittoor-15, Arogyavaram-15
Anantapur	Nov27 th : Nambulipulikunta-25
South Interior Karnataka	
Chikkamagaluru	Oct15 th : Kottigehara-17
Ramanagara	Oct10 th : Magadi-13
Shivamogga	Oct15 th : Hosanagar-21, Hunchadakatte-16, Agumbe Emo-13

CAP experienced 23 days of isolated *heavy* rainfall activity with 5 days of isolated *very heavy* rain and three days of isolated *extremely heavy* rain – On 13th October, under the influence of passage of a deep depression over the BOB, Yanam reported 25 cm of rainfall. On 26th and 27th November, under the influence of the VSCS Nivar, Venkatagiri (Nellore district) reported 24 cm on 26th and Kavali (Nellore district) reported 27 cm on 27th.

In RYS, there were 12 days of isolated *heavy* rainfall activity with 4 days of isolated *very heavy* rain and 2 days of isolated *extremely heavy* rain. On 26th and 27th November, under the influence of VSCS Nivar, Kodur (Cuddapah district) reported 25 cm on 26th, Nambulipulikunta (Anantapur district) and Gurramkonda (Chittoor district) reported 25 cm and 21 cm respectively on 27th.

In SIK, there was 23 days of isolated *heavy* rainfall activity with 14 days of isolated *very heavy* rain and one day of *extremely heavy* rainfall. On 15th October, under the influence of passage of easterly wave trough, Hosanagar (Shivamogga district) reported 21 cm. In Kerala, there were 15 days of isolated *heavy* rainfall activity with 2 days of isolated *very heavy* rain over Alappuzha and Ernakulam districts.

5. District rainfall performance during October-December 2020

District-wise rainfall realised over the subdivisions of TN, KER, CAP, RYS & SIK during October to December 2020 is presented in Fig.5. As seen, all the districts in CAP and RYS received *normal* to *large excess* rainfall during the season. While most districts in CAP and RYS received *excess* rainfall, Krishna district in CAP and Cuddapah district in RYS received *large excess* rainfall and Srikakulam and Prakasam districts in CAP and Anantapur district in RYS received *normal* rainfall. In the TN subdivision, 34 out of 39 districts received *normal* to *excess* rainfall with Cuddalore, Villupuram, Kallakurichi, Thiruvannamalai, Tiruppattur, Chennai, Kanchipuram, Sivaganga and Virudunagar districts coming under *excess* category (29% to 45% excess). Nilgiris, Erode, Namakkal, Tiruchirapalli and Kanyakumari ended up *deficient*.

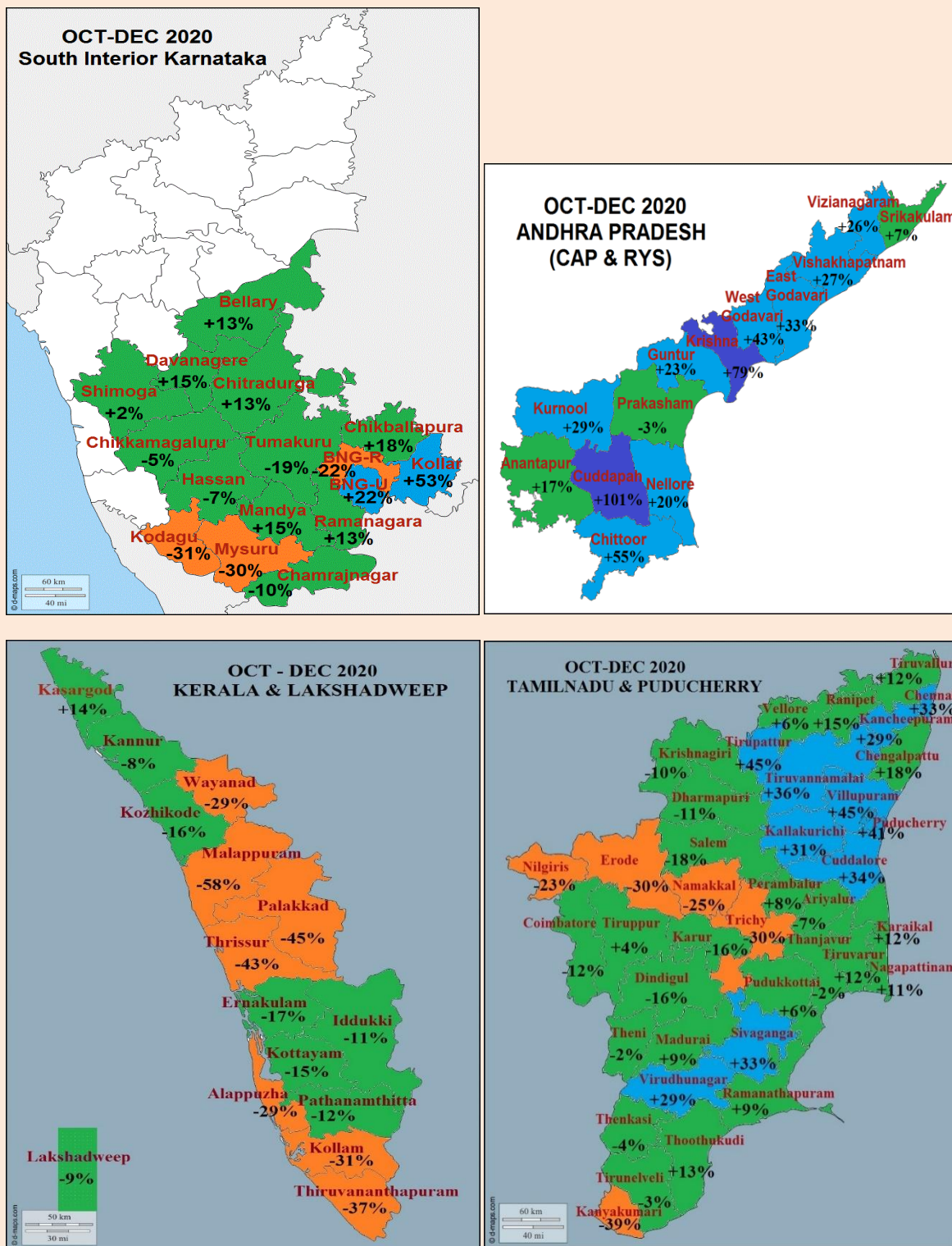


Fig.5 District-wise rainfall performance over the various subdivisions during Oct-Dec 2020

In Kerala, while Idukki, Ernakulam, Pathanamthitta, Kottayam, Kozhikode, Kannur and Kasargod received *normal* rainfall, all other districts came under *deficient* category. In SIK, most

districts received *normal* rainfall excepting Kollar and Bangalore (Urban) which received *excess* rainfall and Mysuru and Kodagu that came under *deficient* category.

6. Standardised Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for monitoring drought and is based on precipitation. This index is negative for dry and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. For October-December 2020, by the end of the season, SPI indicated generally *wet* conditions over the eastern coastal and some adjoining districts of CAP, RYS and TN (Fig.6). Villupuram and Kallakurichi districts in TN, Cuddapah, Chittoor and Anantapur districts in RYS, Krishna and West Godavari districts in CAP came under *moderately* to *severely* wet conditions.

Generally *dry* conditions prevailed over KER and some neighbouring districts of SIK and TN. Whereas Malappuram and Palakkad districts in KER and Kanyakumari district in TN were in *moderately-extremely dry* conditions, all other districts in KER excepting Kasargode which came under *mildly wet* category and Nilgiris, Coimbatore, Erode, Namakkal, Salem, Dharmapuri, Krishnagiri, Karur, Tiruchi, Dindigul districts in TN, Kodagu, Mysuru, Hassan, Tumakuru and Bangalore-rural in SIK came under *mildly dry* category.

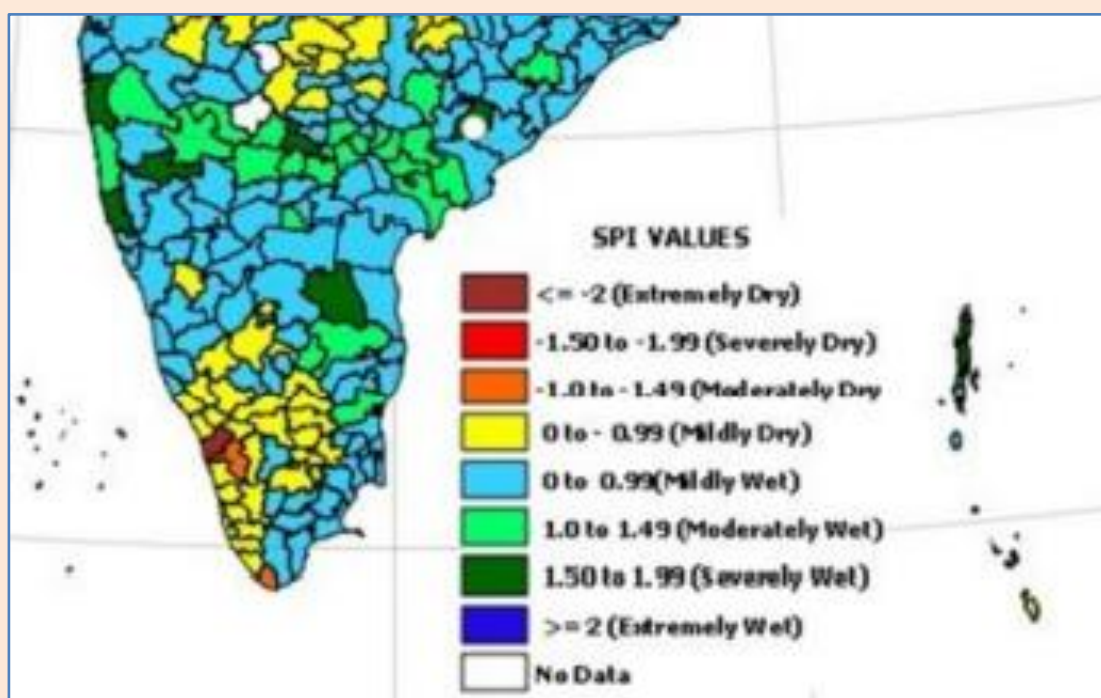


Fig.6: Standardised Precipitation Index for October-December 2020 over the southern peninsular India (Source: CDBI, Postmonsoon season -2020, IMD Pune).

7. Chief circulation features

(a) **Flow pattern over Indian region:** The mean and anomalous wind over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during October-December 2020 are presented in Fig.7(a-c).

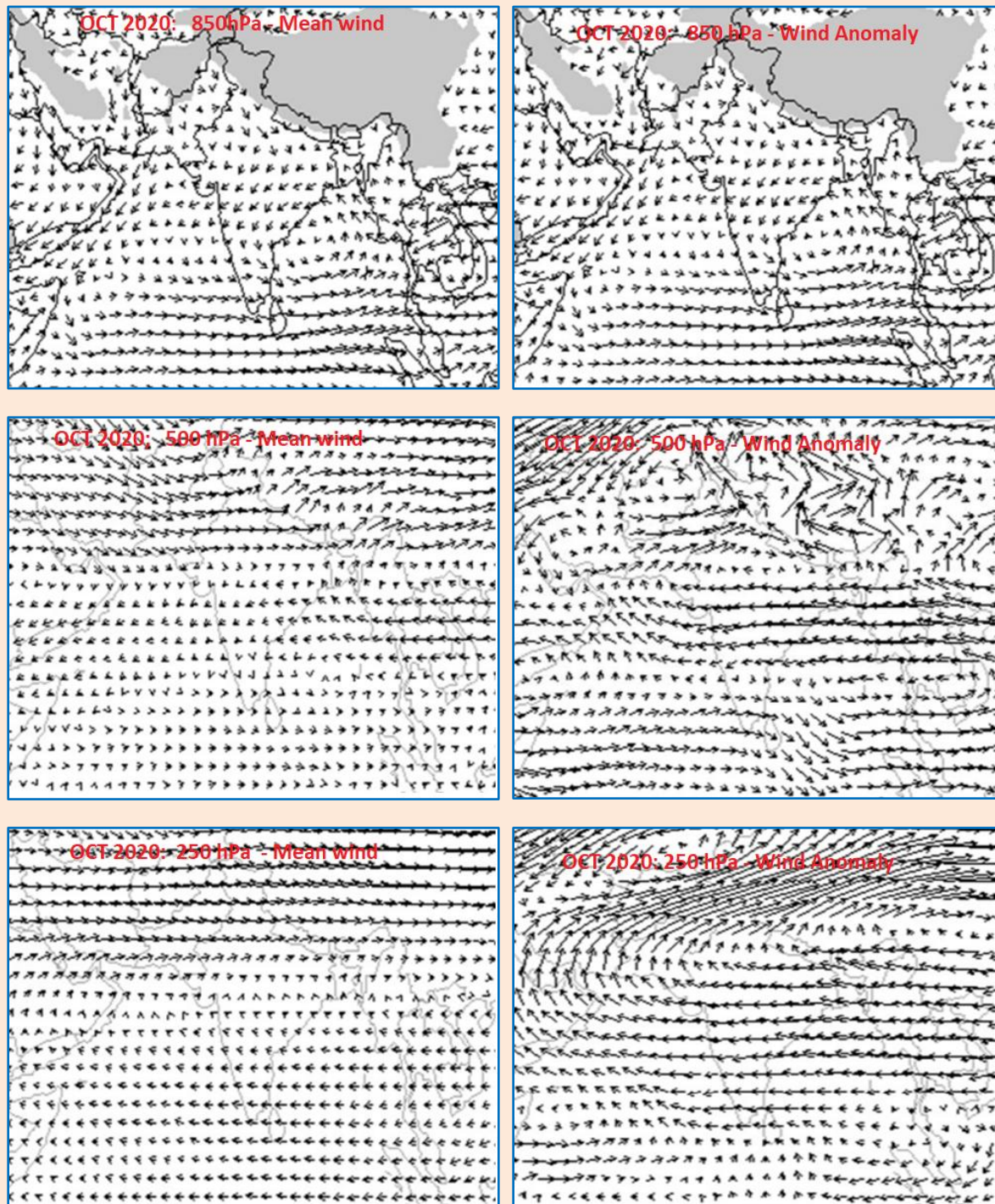


Fig.7a: Mean and anomalous wind pattern over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during October 2020 (Source: Climate Diagnostic Bulletin of India, IMD Pune)

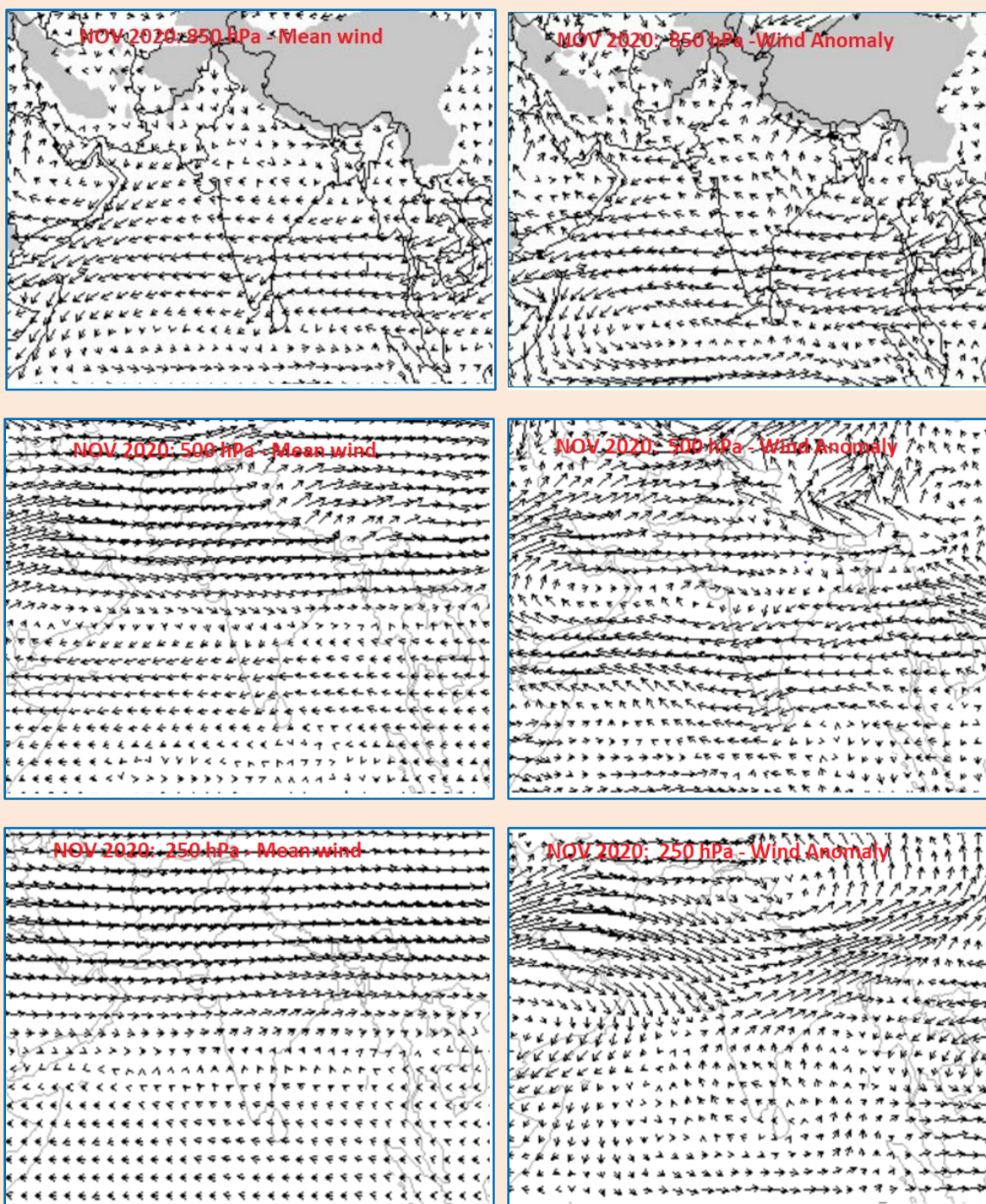


Fig.7b: Mean and anomalous wind pattern over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during November 2020 (Source: Climate Diagnostic Bulletin of India, IMD Pune)

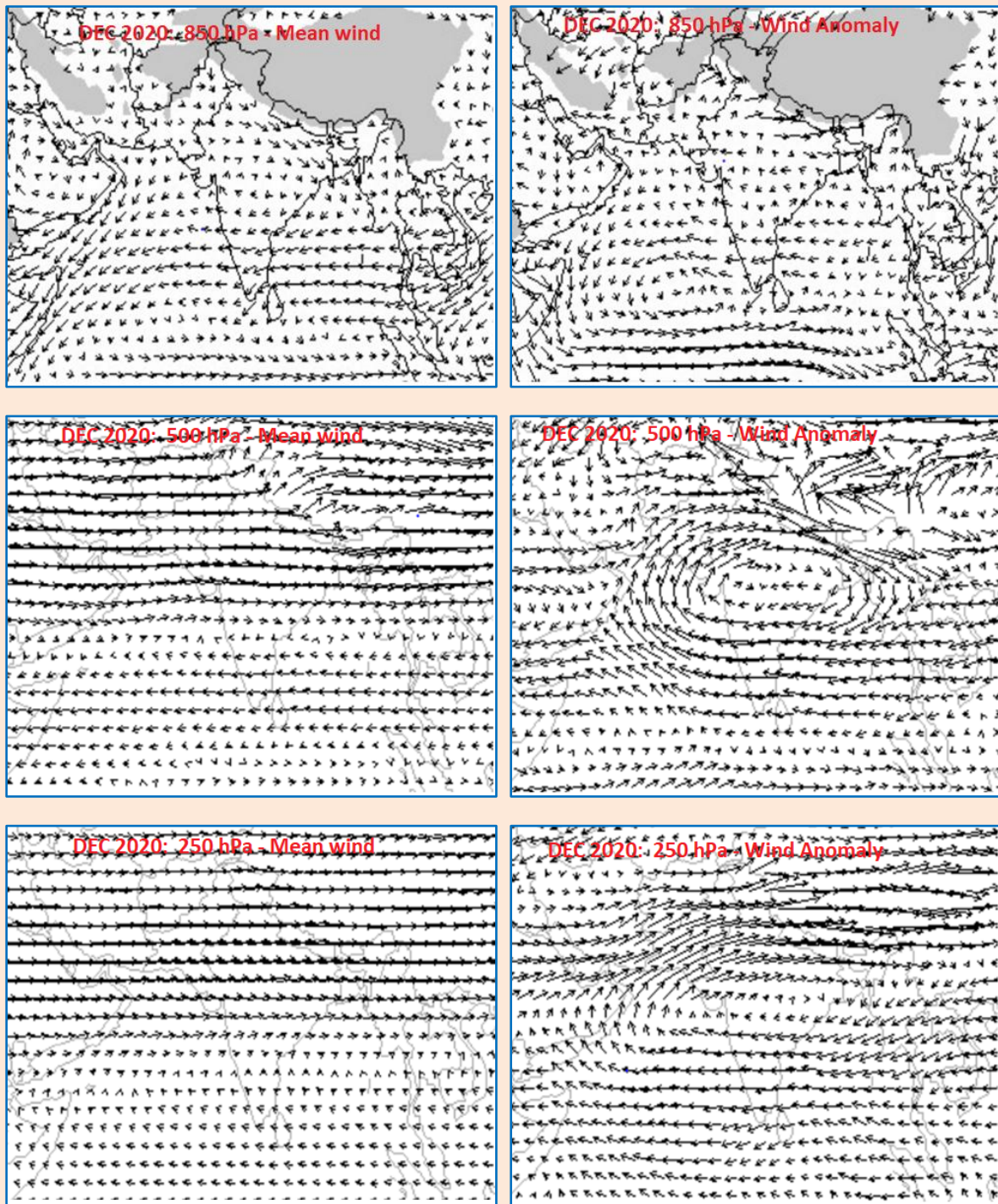


Fig.7c: Mean and anomalous wind pattern over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during December 2020 (Source: Climate Diagnostic Bulletin of India, IMD Pune)

In October, at 850 hPa level, south of 15°N, westerly winds are observed over the southern parts of peninsular India and southern parts of BOB under the influence of an anomalous cyclonic circulation over the BOB and adjoining southern peninsula and westerly anomalies over extreme south peninsula. At 500 hPa level, anomalous anticyclonic circulation is

observed over the northern parts of India which strengthens at 250 hPa level leading to prevalence of easterlies over the Indian region.

In November, at 850 hPa level, easterly anomalies and easterly winds are observed over the southern region. Easterly anomalies are observed over the BOB and southern peninsular region even at 500 hPa level. At 250 hPa, anomalous westerly trough is seen over the northern parts.

In December, at 850 hPa level, easterlies are observed over the southern peninsula and an anomalous cyclonic circulation over the southern parts of the Arabian sea. At 500 hPa, an anomalous anticyclone is observed over the central parts of India leading to easterly anomalies over the southern region. The anomalous anticyclonic circulation is observed at 250 hPa level also.

(b) **Large scale features:** Based on the reports of various global climate monitoring centres, it was noted that during October-December 2020, La Nina conditions (negative SST anomalies) prevailed over the equatorial Pacific region and Indian Ocean Dipole was neutral (Fig.8a&b). MJO was in the western hemisphere during October, in phase 2-4 during the second half of November and generally insignificant in December 2020 (Fig.8c). La Nina conditions over the equatorial Pacific, though, in general, not favourable for good NEM activity, was favourable during the later half of the season and led to extension of NEM activity into January 2021 also. Neutral IOD did not have much influence on the NEM activity.

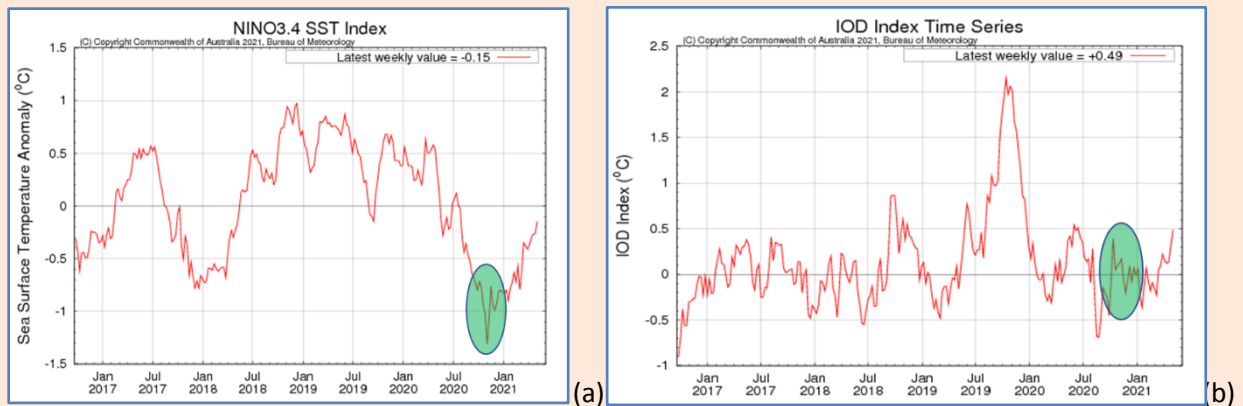


Fig.8a-b: Graphs of (a) SST anomaly over the equatorial Pacific (Nino 3.4 region) and (b) Indian Ocean Dipole Index. Values during October-December 2020 are highlighted by green shading. (Source: Bureau of Meteorology, Australia).

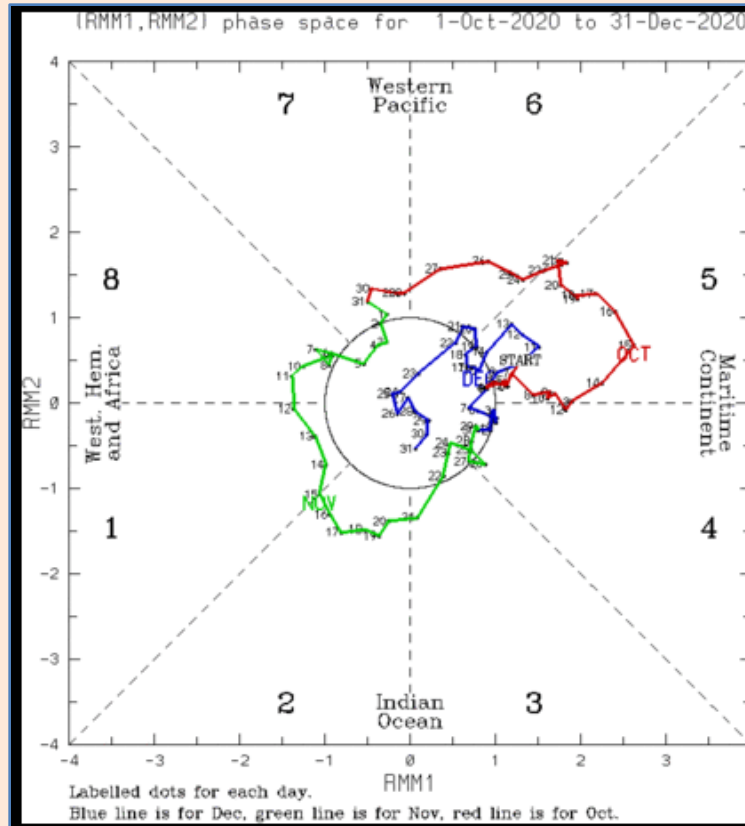


Fig.8c: MJO during Oct-Dec 2020(Source: Bureau of Meteorology, Australia)

MJO was unfavourable for NEM activity in October. It was favourable during the second half of November 2020.

8. Summary

The onset of NEM 2020 over the southeastern parts of peninsular India took place on 28th October [delay of 8 days from the normal date of onset (20 October)]. Despite a late onset, excepting Kerala, all other subdivisions benefited by the NEM (TN, CAP, RYS & SIK) received normal to excess rainfall during the season (Oct-Dec 2020). Under the influence of extended SWM, CAP, RYS & SIK received normal rainfall in October, but, TN & KER ended up deficient during the month. In November, excepting KER, which came under *deficient* category, all other subdivisions received normal / above normal rainfall with RYS recording +122% *excess*. In December all the five subdivisions received normal / above normal rainfall with RYS and TN recording +99% and +87% excess rainfall. Two cyclones – VSCS Nivar and CS Burevi as well as passage of easterly wave trough across peninsular India contributed significantly towards NEM activity during November and December. The NEM season extended into first half of January 2021 also and cessation of NEM rains over the peninsular India took place on 19th January 2021.

Acknowledgements

This report is a compilation of real-time observational data and analytical products generated by various IMD offices including IMD New Delhi, Pune, Hyderabad, Bangalore and Thiruvananthapuram as well as raingauge networks of state government departments. Contribution from all officials involved in generation of data and analytical products used for preparation of this report is duly acknowledged. Use of US-NCEP reanalysis data, analytical product of Bureau of Meteorology, Australia & CIMSS and local media reports are also duly acknowledged.

APPENDIX-(i): Terminologies for Spatial rainfall distribution

WD - Widespread (Most places): 75 % or more number of stations of a region (sub-division) reporting at least 2.5 mm rainfall.

FWD- Fairly widespread (Many places): 51% to 74 % number of stations of a region (sub-division) reporting at least 2.5 mm rainfall.

SCT- Scattered (at a few places): 26 % to 50% number of stations of a region (sub-division) reporting at least 2.5 mm rainfall.

ISOL- Isolated (At isolated places): 25% or less number of stations of a region (sub-division) reporting at least 2.5 mm rainfall.

DRY: No station of a region reported rainfall

APPENDIX-(ii): Terminologies for description of intensity of rainfall

S No.	Terminology	Rainfall range In mm	Rainfall range In cm	Percentile
1	Very light rainfall	Trace -2.4		
2	Light rainfall	2.5-15.5	Upto 1	Upto 65
3	Moderate rainfall	15.6-64.4	02-06	65-95
4	Heavy Rainfall	64.5- 115.5	07-11	95-99
5	Very Heavy Rainfall	115.6-204.4	12-20	99.0-99.9
6	Extremely heavy rainfall	Greater or equal to 204.5 mm	21 cm or more	>99.9
7	Exceptionally Heavy Rainfall	When the amount is a value near about the highest recorded rainfall at or near the station for the month or season. However, this term will be used only when the actual rainfall amount exceeds 12 cm.		

APPENDIX-(iii): Description of NEM rainfall activity

Active: Fairly widespread to widespread sub-divisional rainfall with rainfall more than 1½ to 4 times the normal with at least two stations reporting more than or equal to 5 cm in coastal Tamil Nadu, south coastal Andhra Pradesh and 3 cm elsewhere in the NEM region.

Vigorous: Fairly widespread to widespread sub-divisional rainfall with rainfall more 4 times the normal with at least two stations reporting more than or equal to 5 cm in coastal Tamil Nadu, south coastal Andhra Pradesh and 3 cm elsewhere in the NEM region.