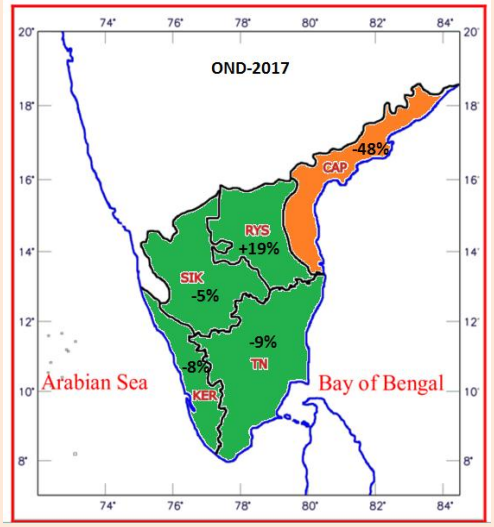
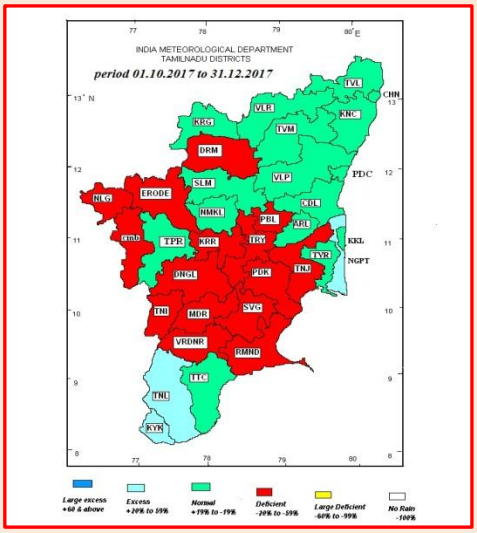
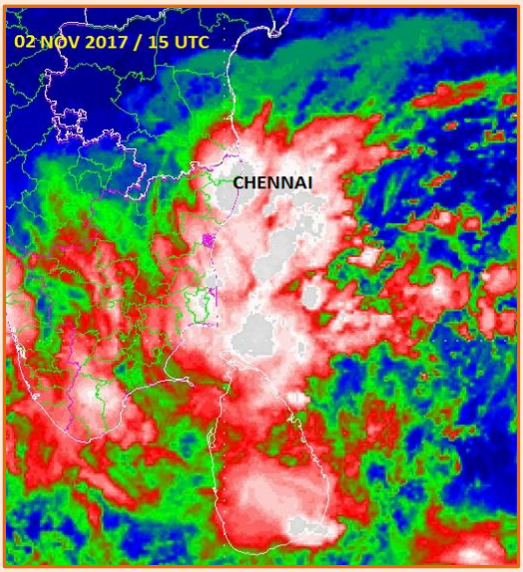
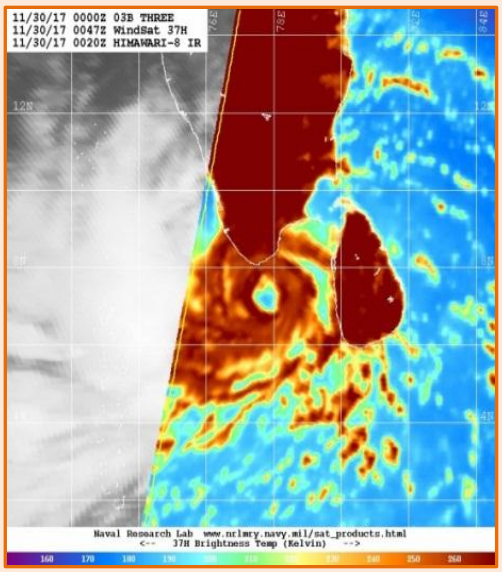
Government of India
Earth System Science Organisation
Ministry of Earth Sciences
India Meteorological Department

REPORT ON NORTHEAST MONSOON – 2017









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Regional Meteorological Centre, Chennai

1. Background

The Indian southwest monsoon (SWM) season of June to September is the chief rainy season for India and 75% of the country's annual rainfall is realised during this season. However, for the extreme southeastern state of Tamil Nadu and the Union Territory of Puducherry (PDC) which together are considered as the meteorological subdivision of Tamil Nadu (TN), the normal SWM seasonal rainfall realised is only about 35% (317.2 mm) of its annual rainfall (914.4 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% (438.2 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 the TN subdivision and also contribute significantly to NEM rainfall. As such, the NEM season assumes importance from the agricultural as well as cyclone disaster management perspectives. Inland flooding associated with heavy rainfall episodes during the season is also a cause for concern. Further, the NEM seasonal rainfall shows a high degree of variability with 27% co-efficient of variation. The recent NEM seasons of 2015 and 2016 saw two extreme seasonal rainfall scenario. Whereas the NEM 2015 was +52% excess over the TN sub division with some extremely heavy rainfall activity and unprecedented floods over the north coastal districts of Chennai, Kanchipuram and Thiruvallur, the NEM 2016 was largely deficient at -62% and was the worst deficient scenario in the last 140 years. The excess NEM 2015 occurred under strong El Nino and positive-normal Indian Ocean Dipole (IOD) conditions which are generally associated with good NEM performance. But, the largely deficient OND 2016 occurred under weak La Nina over the equatorial Pacific and negative to near normal IOD over the Indian Ocean region. However, during OND 2017, the ENSO and IOD were not expected to modulate the NEM performance as neutral ENSO and IOD conditions prevailed. This report presents the salient features of NEM over the meteorological subdivisions of TN, Coastal Andhra Pradesh (CAP), Rayalaseema (RYS), South Interior Karnataka (SIK), and Kerala (KER) during October-December 2017.

2. Onset phase

Normally, the onset of NEM takes place over coastal Tamil Nadu (CTN) by 20th October after the withdrawal of SWM up to about 15°N latitude. Prior to the onset of NEM over CTN, the low level winds reverse from southwesterlies (during the SWM) to northeasterlies along CTN and south coastal Andhra Pradesh (SCAP). During the year 2017, due to extended SWM activity over the peninsular India, withdrawal of SWM up to 15°N latitude took place only around 25th October when it withdrew from the entire country. Simultaneously, setting in of easterlies in the lower tropospheric levels over the southern peninsula took place and with the

prevalence of an upper air cyclonic circulation over southeast Tamilnadu and neighbourhood and another cyclonic circulation over Lakshadweep area and neighbourhood on 25th October, conditions became favourable for commencement of northeast monsoon rains during the subsequent 48 hrs. Low level wind flow pattern, mean sea level pressure and clouding associated with the onset of NEM 2017 are presented in Fig.1(a-d). Westerly wind in the lower levels over the BOB and southern peninsular India during 01st-25th October 2017 became easterly subsequently during 26th to 31st October 2017. 850 hPa streamline analysis as on 23rd and 27th October 2017 indicate the wind reversal from the westerly to easterly regime during the onset phase of NEM 2017. A low pressure area (LOPAR) at the mean sea level formed over the Comorin area and neighbourhood on 27th October which was seen as two separate LOPARs, one over the southwest BOB and adjoining Sri Lanka and the other over the Lakshadweep area on 28th (Fig.1d). On 27th October, the NEM rains commenced over TN, KER and adjoining areas with *widespread (WS*) rainfall activity over Kerala and *scattered (SCT*) rainfall activity over TN and SIK. The cloudiness associated with the LOPARs are indicated in the INSAT-3D infra-red cloud imageries (Fig.1d). Even though the onset of NEM 2017 was delayed by a week, rainfall activity during the onset phase of NEM 2017 was quite significant as detailed in Table-1.

Table-1 Rainfall activity over Tamil Nadu during 27 Oct to 06 Nov 2017

Date	Spatial distribution	NEM Activity	Heavy rainfall occurrence
27-Oct-2017	SCT	Normal	Isolated *heavy*
28-Oct-2017	FWS	Normal	Isolated *heavy*
29-Oct-2017	SCT	Weak	--
30-Oct-2017	ISOL	Normal	Isolated *heavy*
31-Oct-2017	FWS	Vigorous	Scattered *heavy* with isolated *very heavy* to *extremely heavy* rainfall activity over CTN
01-Nov-2017	FWS	Active	Isolated *heavy*
02-Nov-2017	SCT	Normal	Isolated *heavy* to *very heavy*
03-Nov-2017	FWS	Active	Scattered *heavy* with isolated *very heavy* to *extremely heavy* rainfall activity over CTN
04-Nov-2017	SCT	Normal	Isolated *heavy* to *very heavy*
05-Nov-2017	WS	Active	Isolated *heavy* to *very heavy*
06-Nov-2017	WS	Active	Isolated *heavy* to *very heavy*

***WD**: Widespread; **FWD**: Fairly Widespread; **SCT**: Scattered; **ISOL**: Isolated;*
(Note:Kindly refer Appendix(i) for explanations on terminologies used for categorization of spatial rainfall distribution and Appendix (ii) & (iii) for description of *heavy* rainfall and NEM activity)

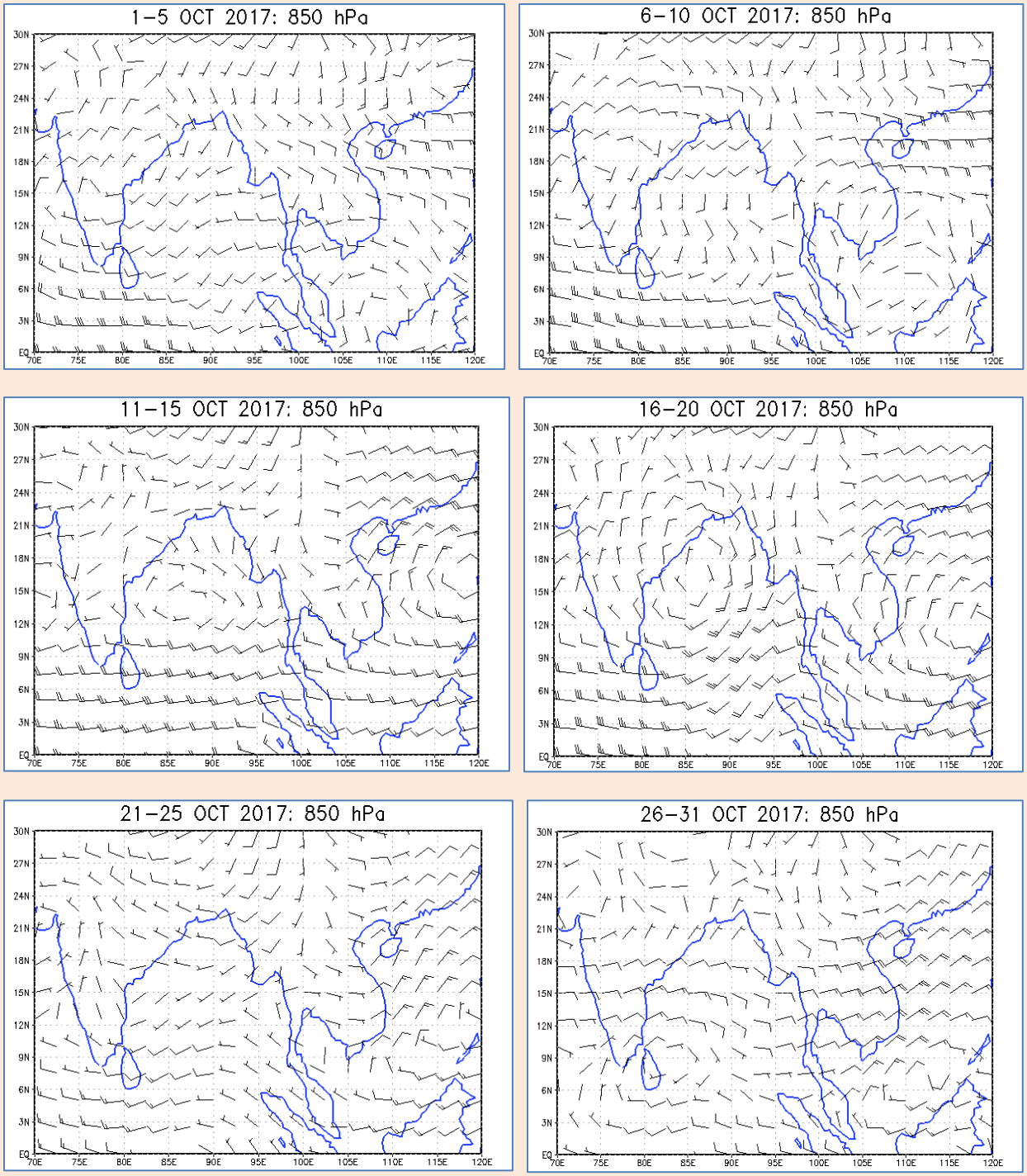


Fig.1a NCEP reanalysis 850 hPa pentad mean wind (kt) during 01-25 Oct 2017 and mean wind (kt) during 26-31 October 2017

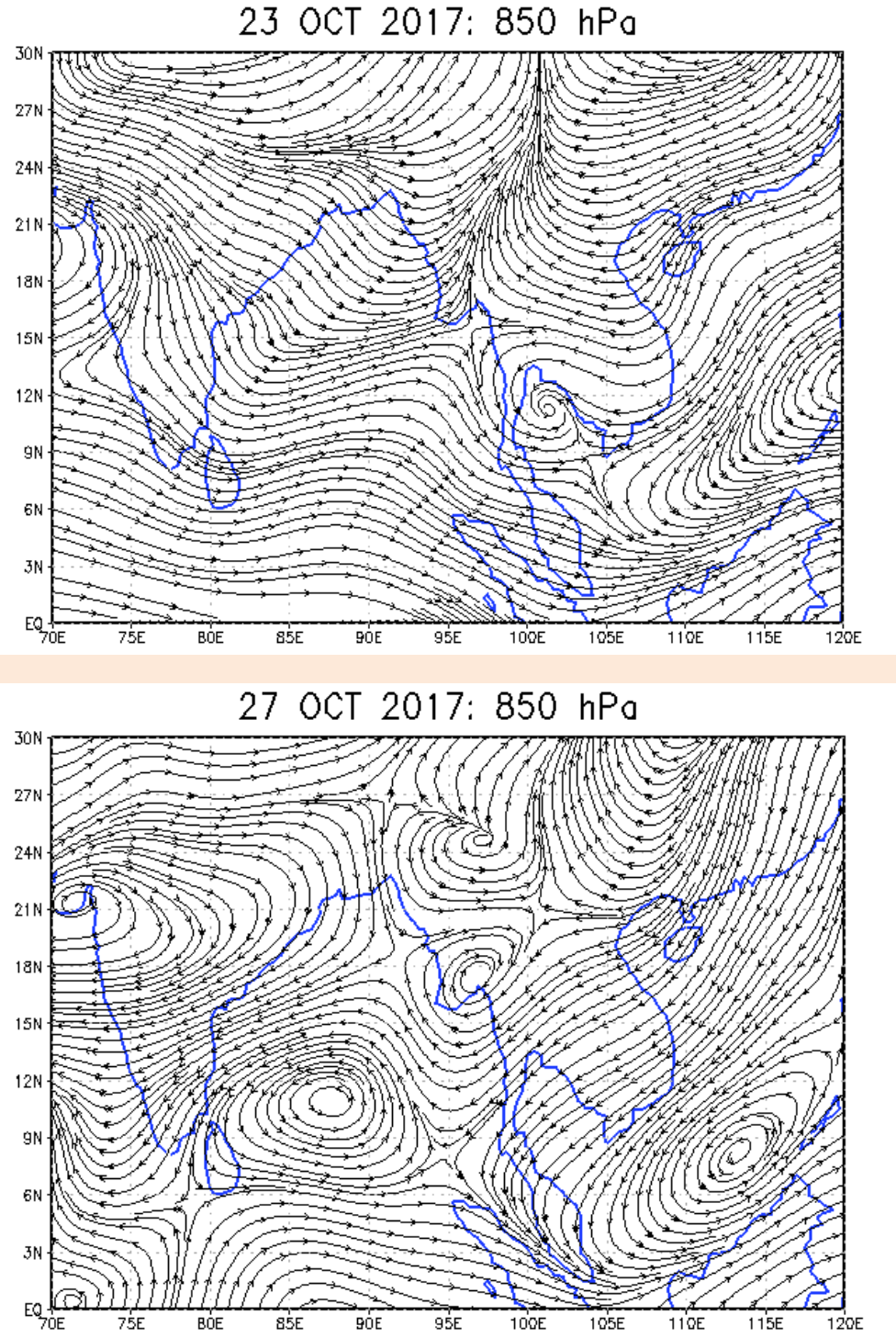


Fig.1b NCEP reanalysis 850 hPa streamline analysis indicating reversal wind over peninsular India during the onset phase of NEM 2017 (23rd & 27th October)

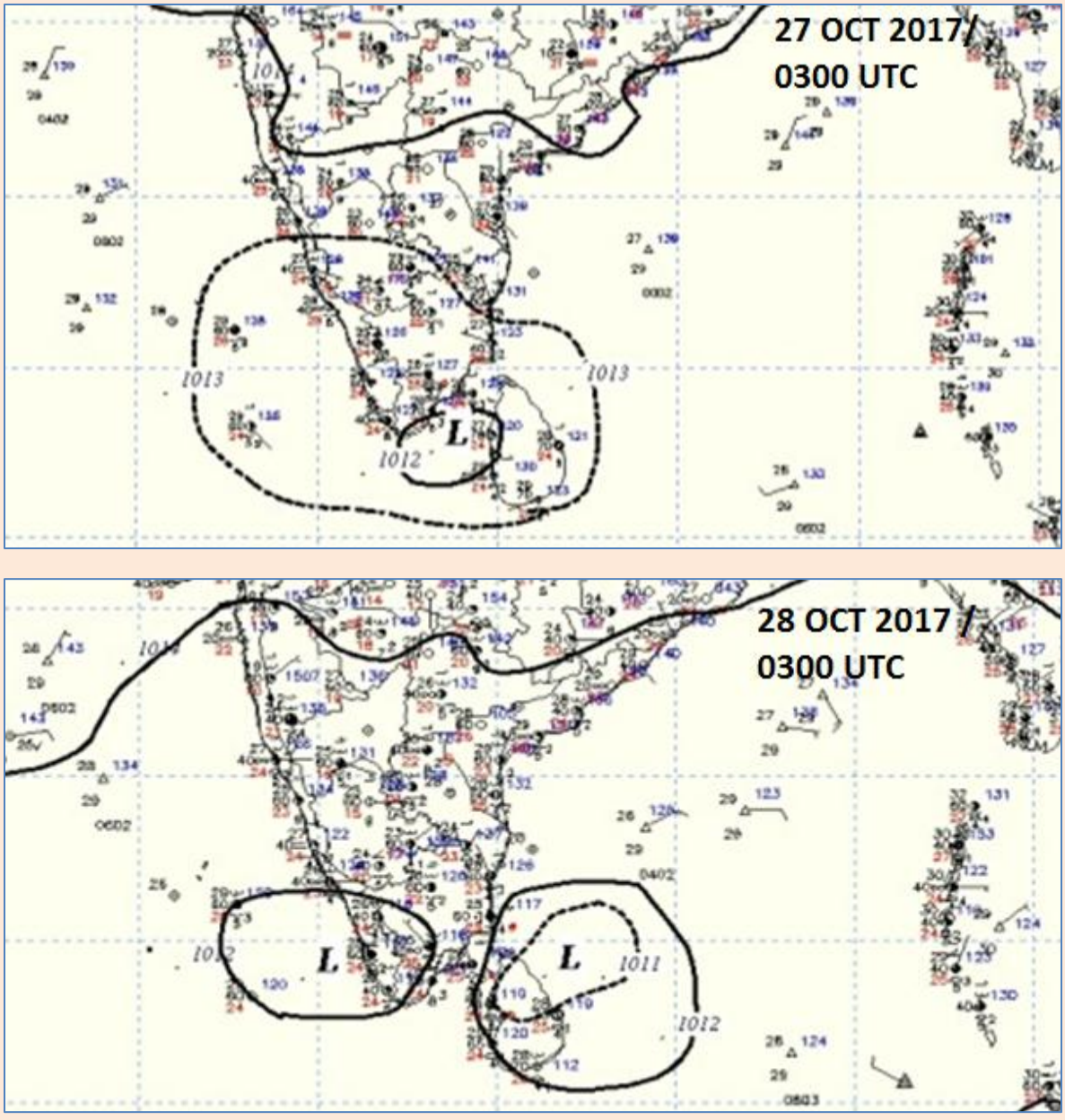


Fig.1c Mean sea level pressure analysis charts as on 27-28 October 2017, 0830 IST

During the period from 27th October to 06th November, there were 6 days of *fairly widespread* (*FWS)* to *WS* rainfall over TN with 5 days of *active* to *vigorous* NEM conditions. There were 6 days of *very heavy* rainfall occurrences with *extremely heavy* rainfall events on two days. Sirkali (Nagapattinam district) recorded 31 cm of rain as on 24 hours ending 0830 IST of 31st October and Chennai (Mylapore-DGP office) recorded 30 cm of rain as on 24 hours ending 0830 IST of 03rd Nov 2017. GPM satellite-Gauge merged rainfall depicting rainfall amount ≥ 1 cm/day during the onset period (27 & 28 October 2017) and the subsequent wet spell during 31 October to 05 November is presented in Fig.1e. INSAT-3D and Doppler Weather Radar (DWR) Chennai

reflectivity associated the extremely heavy rainfall events on 31st October and 03 November are presented in fig.1f.

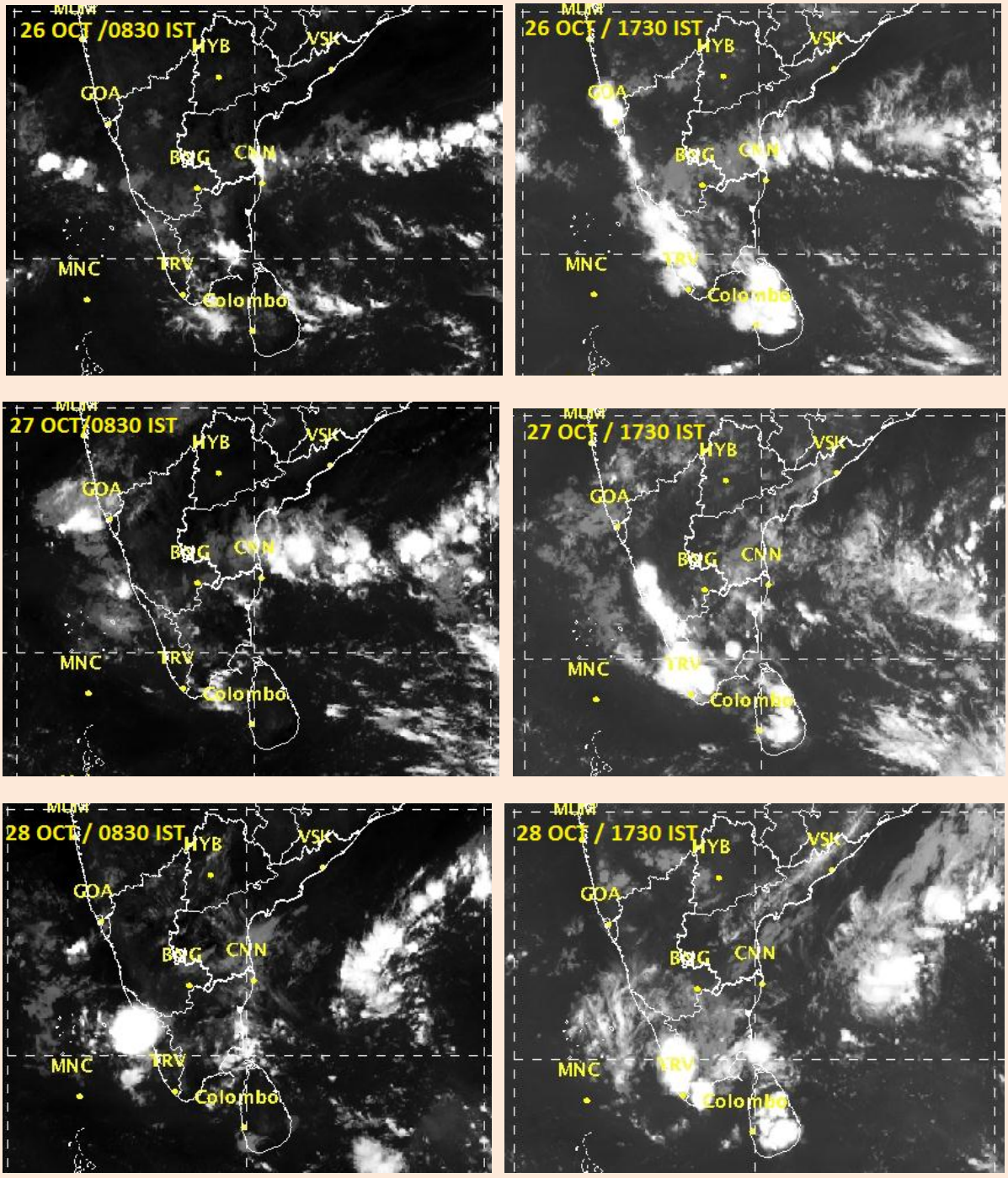


Fig.1d INSAT-3D infra-red imageries during 26-28 October 2017

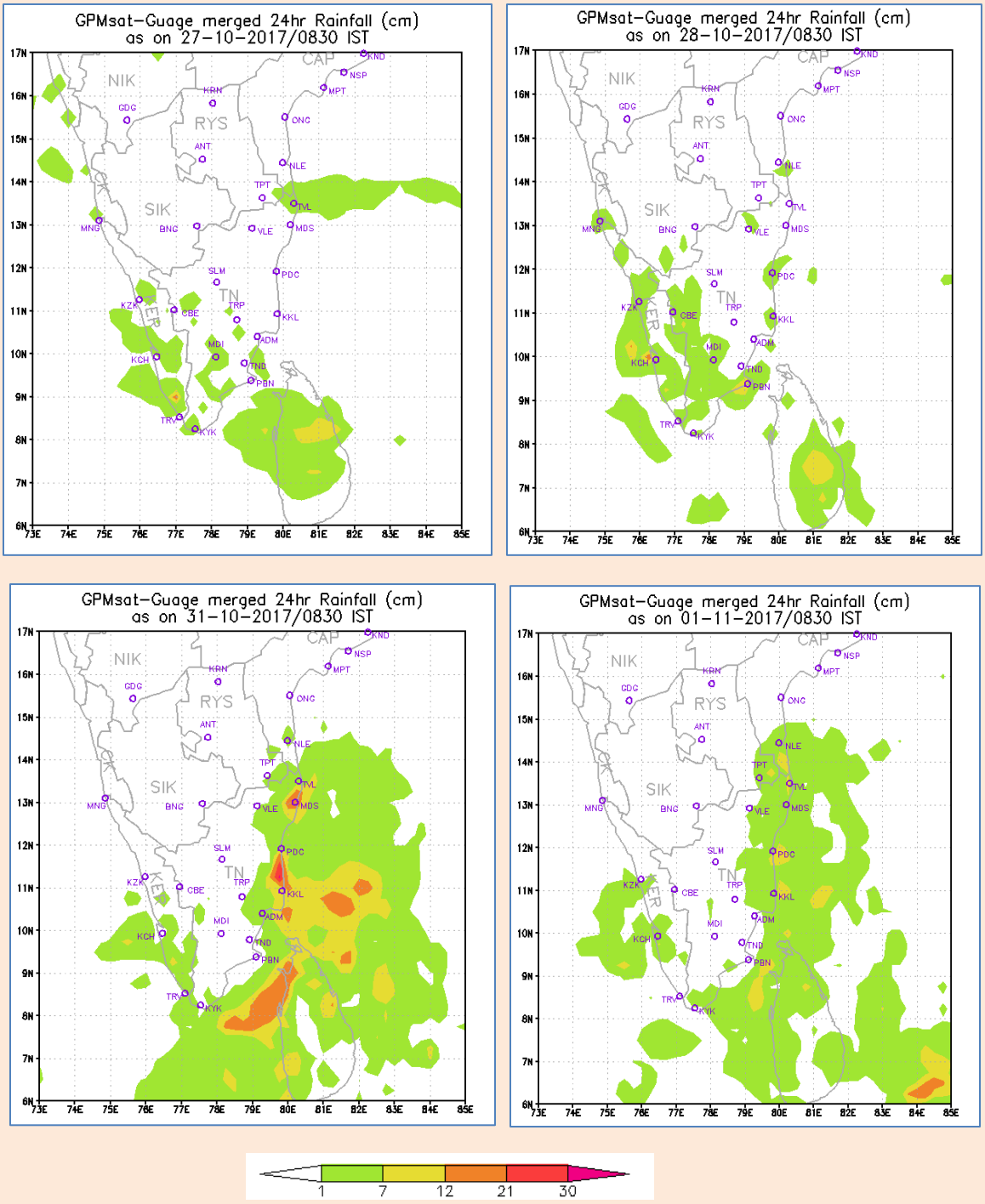
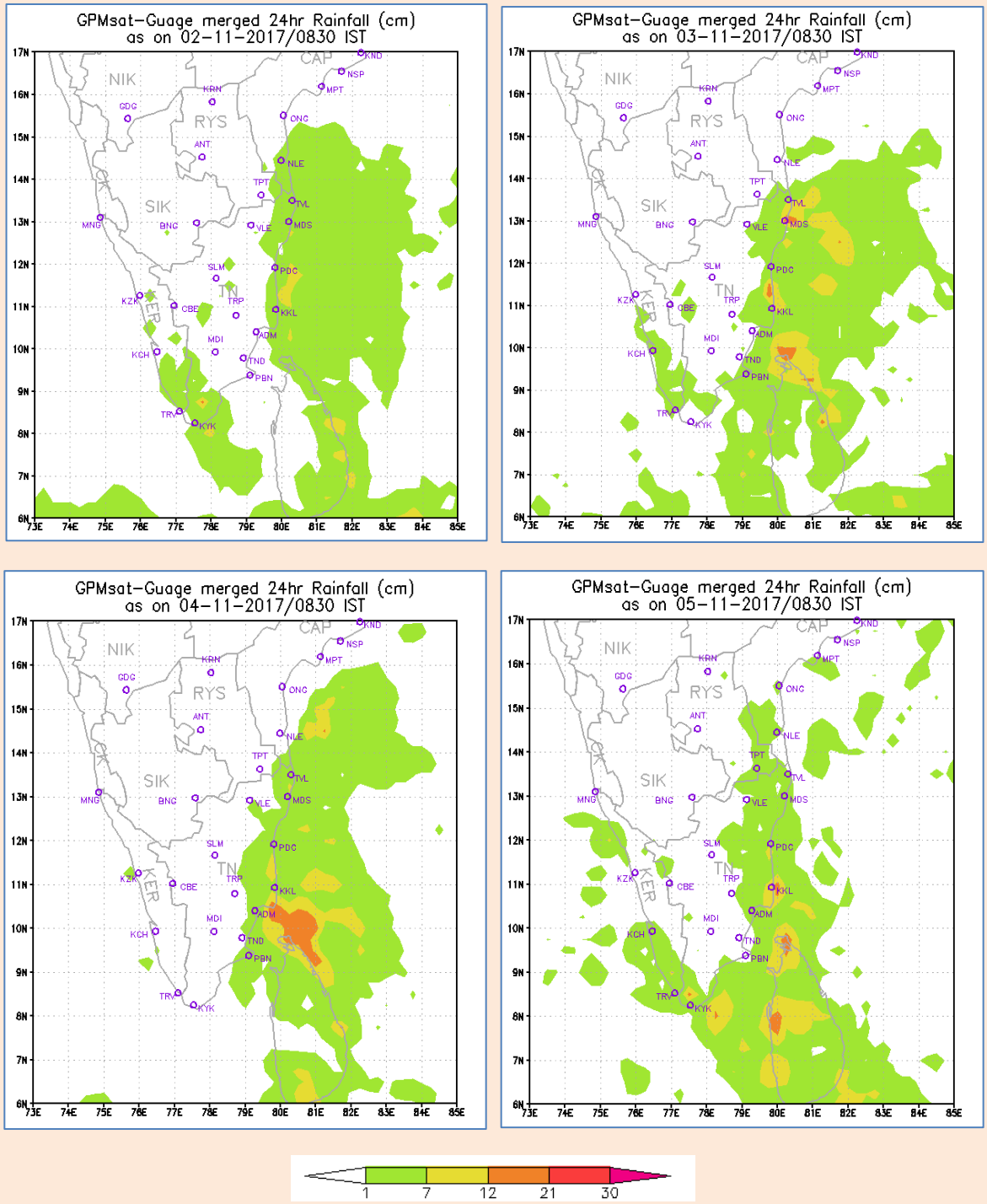


Fig.1e GPM satellite+Gauge merged 24-hr rainfall (in cm) as on 27-28, 31 Oct, 01-05 Nov 2017, 0830 IST.


GPMsat-Guage merged 24hr Rainfall (cm)
as on 02-11-2017/0830 IST
GPMsat-Guage merged 24hr Rainfall (cm)
as on 03-11-2017/0830 IST
GPMsat-Guage merged 24hr Rainfall (cm)
as on 04-11-2017/0830 IST
GPMsat-Guage merged 24hr Rainfall (cm)
as on 05-11-2017/0830 IST
NIK
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CAP
KND
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BNG
VLE
SLM
PDC
KZK
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Fig.1e contd…

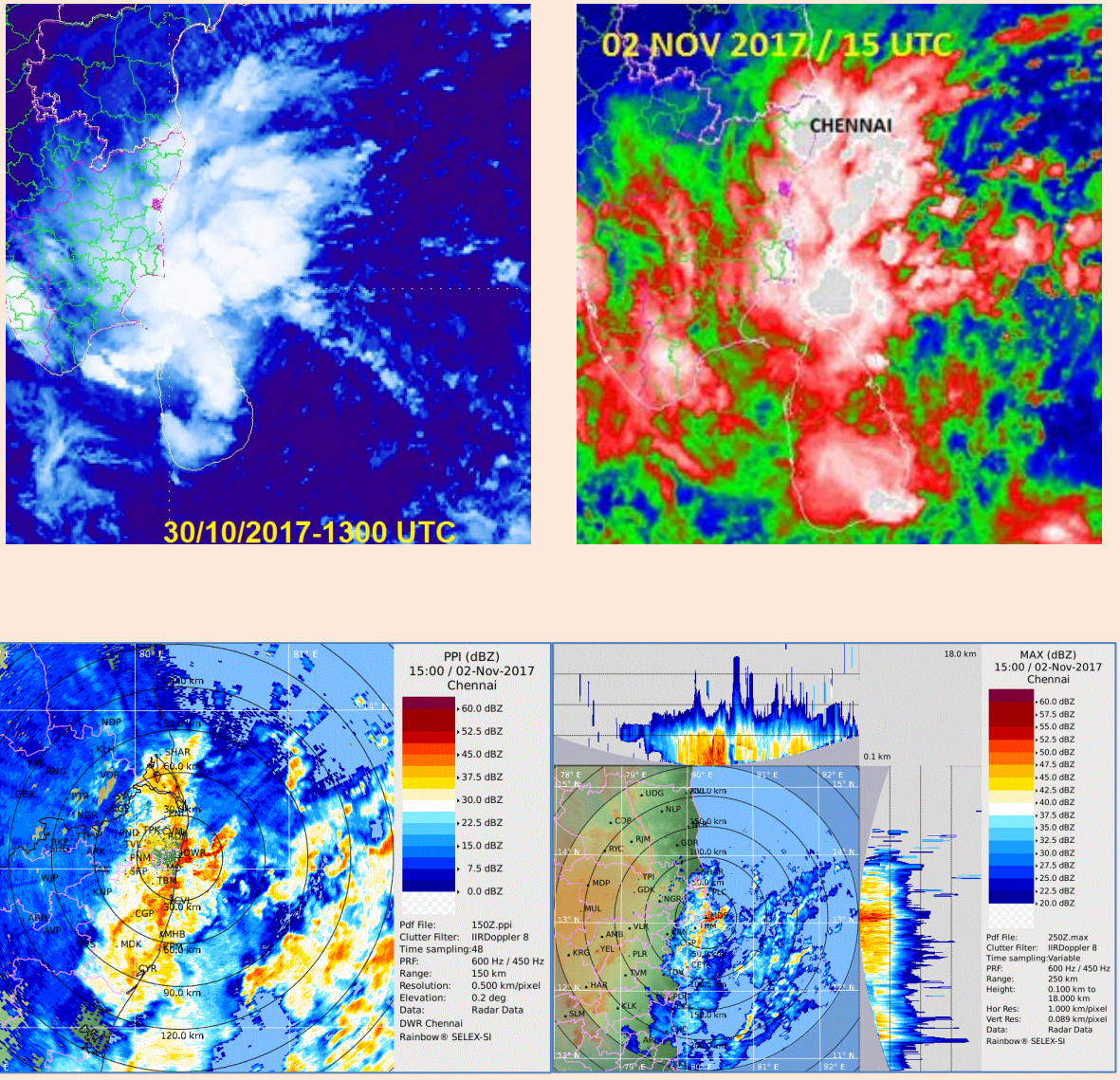


Fig.1f INSAT-3D IR imageries as on 30 Oct / 1300 UTC and 02 Nov 1500 UTC and DWR Chennai PPI and Max-Z products based on 1500 UTC of 02-11-2017

The *extremely heavy rainfall* event over Sirkazhi (31 cm as on 24-hr ending 0830 IST of 31st October) and that over Chennai (30 cm as on 24-hr ending 0830 IST of 03rd November) were associated with upper air cyclonic circulation over the southwest BOB and adjoining Sri Lanka coast which developed into a low pressure area on 02nd November over the same region. Active-vigorous NEM conditions and FWS rainfall occurred over TN on both the days.

The extremely heavy rainfall event over Chennai on 02nd November was associated with meso-scale activity embedded within the synoptic scale LOPAR during its development stage. Whereas the rainfall recorded at Chennai-Marina (DGP's office complex) was 30 cm/day, the

rainfall recorded at Chennai-Nungambakkam was 18 cm/day. The chief rainfall period of this *extremely heavy rainfall* event was just about 6-7 hours between 1900 IST of 02nd to 0200 IST of 3rd November 2017 (Fig.1g).

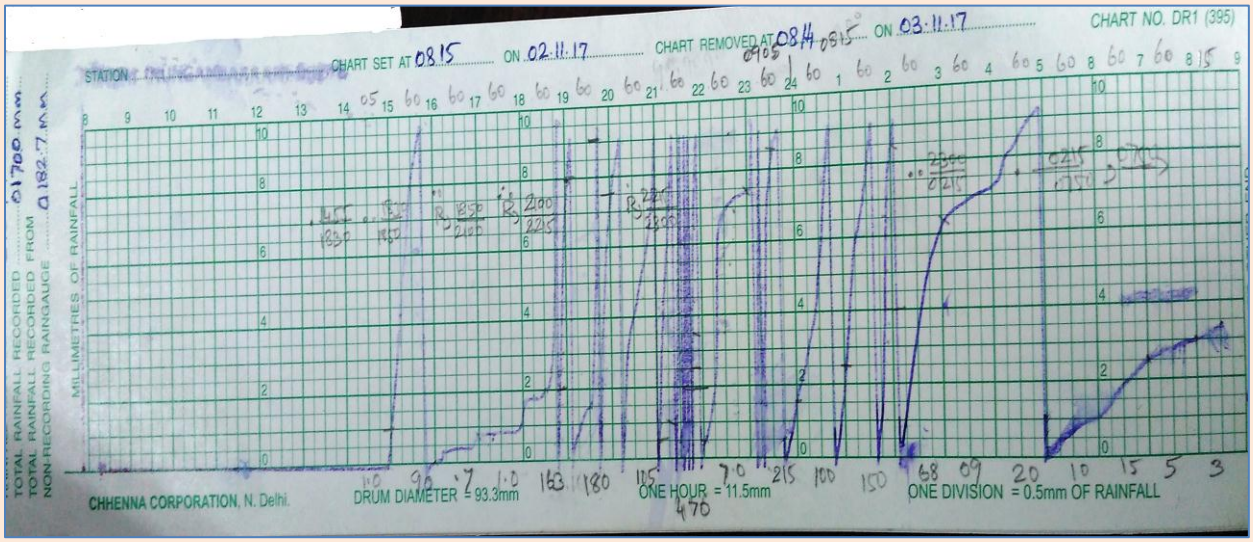


Fig.1g Rainfall recorded by the self-recording rain gauge at Chennai-Nungambakkam during the period 0815 IST of 02nd to 0815 IST of 03rd Nov 2017

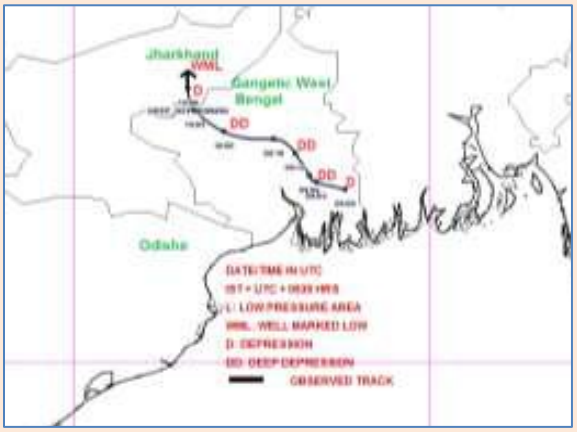
3. Synoptic scale weather systems during Oct-Dec 2017

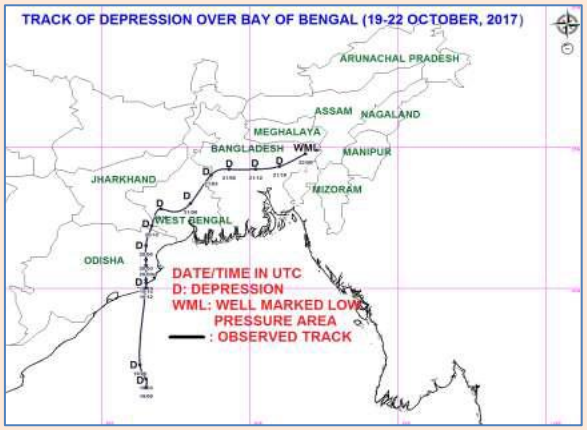
During Oct-Dec 2017, five synoptic scale systems formed over the BOB (2-Depressions (D), 2-Deep Depressions (DD), 1-Very Severe Cyclonic Storm (VSCS) 'Ockhi'). Of these, 1-D and 1-DD formed in the westerly flow regime prior to the onset of NEM. Tracks of these systems are presented in Fig.2. Brief life history of these systems is as follows:

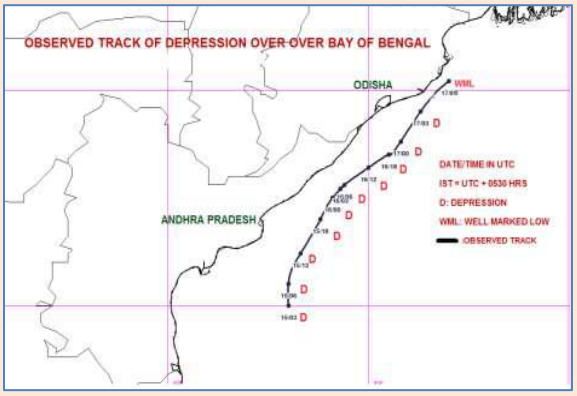
(i) ***Deep depression over land (09-10 Oct):*** A LOPAR formed over North BOB and adjoining south Bangladesh on 8thOctmorning. It lay as a well marked low pressure area (WML) over north BOB and adjoining coastal areas of Bangladesh & West Bengal in the same evening. It concentrated into a D in the early morning of 9thOct over the Gangetic West Bengal (GWB) and adjoining north BOB. Moving northwestwards, it intensified into a DD over GWB in the morning of 9th. It moved nearly north-northwestwards and weakened into a D around noon of 10th and into a well marked low pressure area over northeast Jharkhand and adjoining West Bengal in the evening of the same day. It became less marked on 11th Oct.

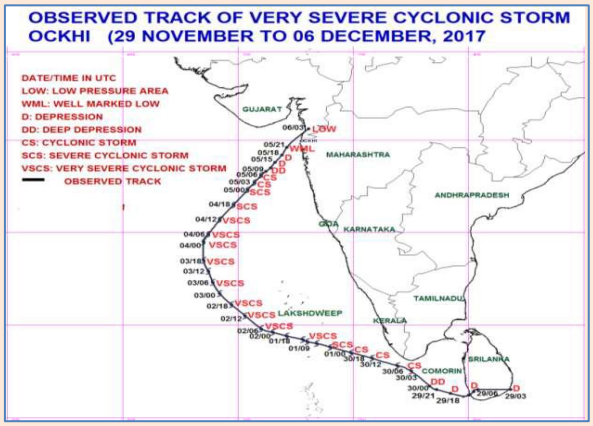
(ii) ***Depression over BOB (19-22 Oct***): A LOPAR formed over central BOB in the morning of 15th Oct. It lay as a WML over central and adjoining south BOB in the morning of 17th. It concentrated into D in the early hours of 19th over westcentral BOB. Moving nearly northwards, it crossed Odisha coast close to Paradip in the late evening of 19th. Subsequently, it recurved and moved northeastwards across Gangetic West Bengal and Bangladesh. It weakened

into a WML over northeast Bangladesh and adjoining Meghalaya & South Assam in the early morning of 22nd Oct.









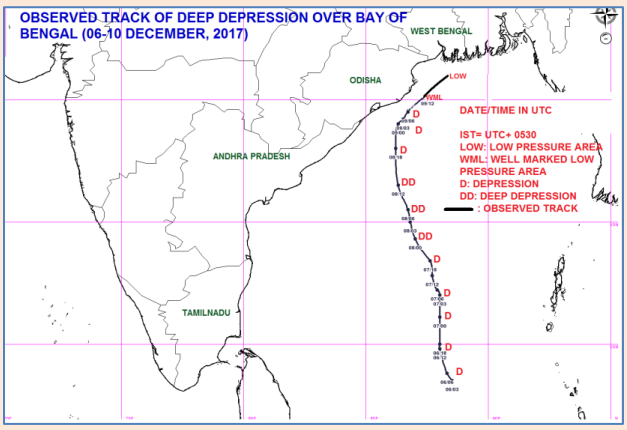


Fig.2 Observed tracks of (i) *Deep depression over land (09-10 Oct)* , (ii) *Depression over BOB (19-22 Oct*), (iii) *Depression over BOB (15-17 Nov)*, (iv) *VSCS Ockhi (29 Nov-06Dec)*, (v) *Deep depression over BOB (06-09 Dec)* (Source: IMD-Preliminary reports on these systems, www.rsmcnewdelhi.imd.gov.in)

(iii) ***Depression over BOB (15-17 Nov):*** A LOPAR formed over southwest BOB and neighbourhood in the morning of 10thNov. It lay as a WML over the southwest BOB and neighborhood in the morning of 13th. It further concentrated into a D over westcentral BOB off Andhra Pradesh on 15th. Moving nearly north-northeastwards, it weakened into a WML over northwest BOB off Odisha Coast on 17th Nov.

(iv) ***VSCS Ockhi (29 Nov - 06Dec):*** A LOPAR formed over southwest BOB and adjoining areas of south Sri Lanka & equatorial Indian Ocean in the forenoon of 28thNov. It became a WML in the early morning of 29thover the same region. Under favourable environmental conditions, it concentrated into a D over southwest BOB off southeast Sri Lanka coast in the forenoon of 29thNov. Moving westwards across Srilanka, it emerged into Comorin area in the evening of 29thand intensified into a DD in the early hours of 30thNov. It further moved northwestwards and intensified into a Cyclonic Storm (CS) '***Ockh***i' in the forenoon of 30thNov over the Comorin area. At about 0830 IST of 30th Nov, it was centred at about 60 km south of Kanyakumari. It caused extensive damages over Kanyakumari and adjoining areas of south coastal Tamilnadu as well as Thiruvananthapuram and adjoining areas of south Kerala. Very to extremely heavy rainfall occurred over Tamilnadu and Kerala on 30th Nov and 01st Dec. Moving westwards, ***Ockhi*** further intensified into a Severe Cyclonic Storm (SCS) over Lakshadweep area in the early morning of 01stDec and into VSCS over southeast Arabian Sea to the west of Lakshadweep (LAK) in the afternoon of 01st Dec. Moving northwestwards, it attained its peak intensity of 150-160 kmph gusting to 180 kmph in the afternoon of 2ndDec with lowest central pressure of 976 hPa. It moved north-northwestwards for some time and then recurved north-northeastwards and maintained its intensity till early morning of 03rdDec. It then continued to move north-northeastwards and weakened gradually. It crossed south Gujarat coast between Surat and Dahanu as a WML around early morning of 6thDec. INSAT-3D infra-red imagery and U.S Naval Research Laboratory, microwave imagery (Windsat 37 GHz), ISRO, Thiruvananthapuram, Doppler Weather Radar (DWR) reflectivity product in association with the cyclone Ockhi when it was closest to the extreme south Tamil Nadu and Kerala coasts on the morning of 30th Nov 2017 are presented in Fig.3a.

Adverse weather associated with the system:

Heavy rainfall occurred over Tamil Nadu, Kerala and Lakshadweep in association with the passage of cyclone Ockhi. Several areas of south coastal Tamil Nadu experienced inland flooding and inundation due to heavy (≥ 7 cm/day) to very heavy (≥ 12 cm/day) rainfall on 30th Nov and 01st Dec 2017. Extremely heavy rainfall (≥ 21 cm/day) has been recorded at Papanasam (45 cm) and Manimutharu (38 cm) in Tirunelveli district of south Tamil Nadu and at Aryankavu (26 cm) in Kollam district of Kerala as on 24-hr ending 0830 IST of 01st Dec 2017; at Sathanur dam (23 cm) in Thiruvannamalai district of north interior Tamil Nadu on 2nd Dec 2017. The subdivisional rainfall figures of TN improved from -17% as on 29th November to +5% as on 02 December 2017.

Gale wind of the order of 65-75 kmph gusting to 85 kmph over KYK and TRV during 30thNov-01stDec 2017 and gale winds of the order of 100-160 kmph gusting to 180 kmph over LAK islands during 01st-02ndDec caused extensive damages to electrical poles, transformers, agricultural plantation, mechanized and country boats of fishermen, houses and roads aside from uprooting of thousands of trees. Heavy rainfall occurrences over Tamil Nadu, Kerala and Lakshadweep associated with the passage of the cyclone are presented in Table-2 and a few photographs and media reports depicting the damages due to the cyclone are presented in Fig.3b.

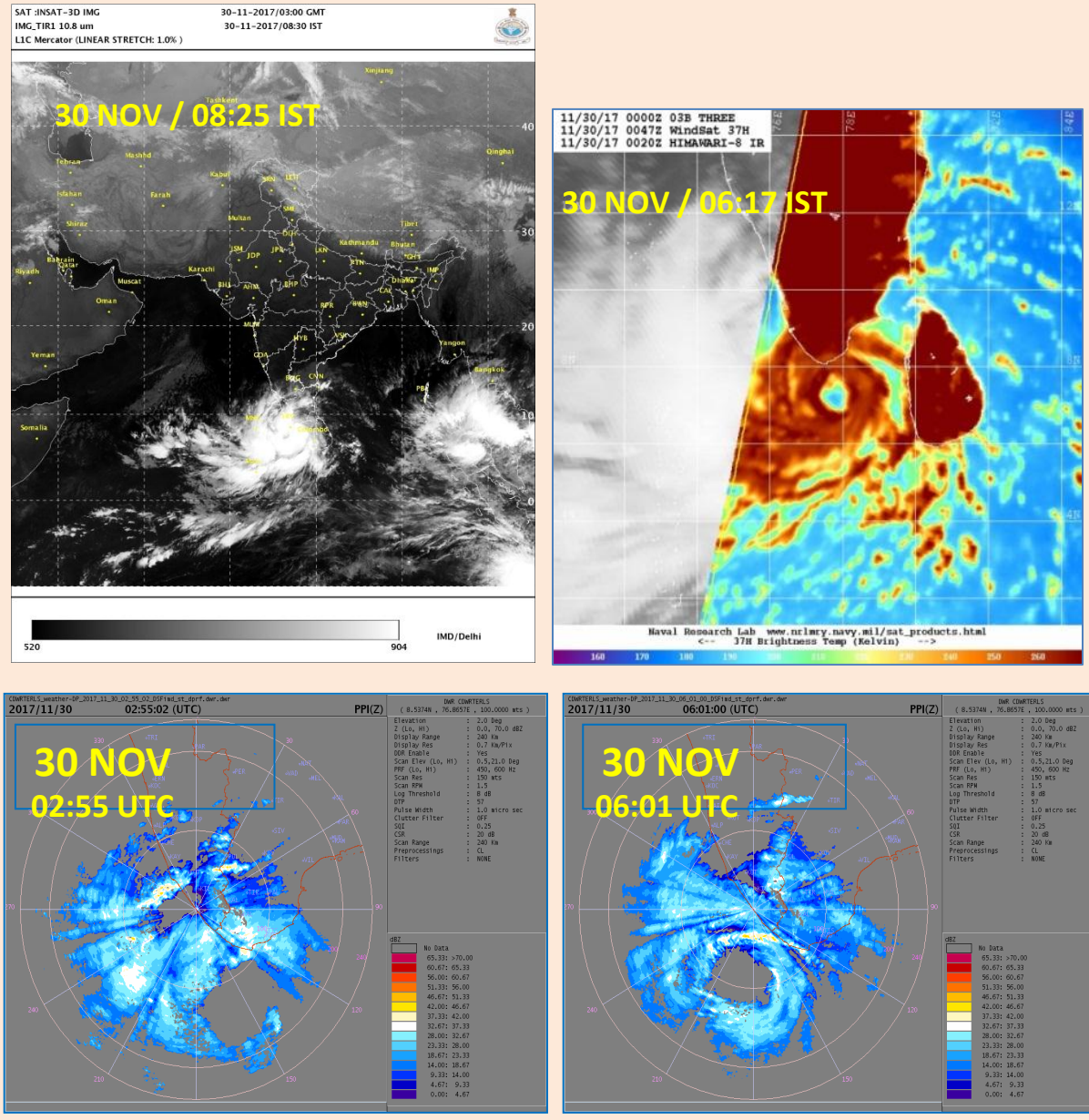


Fig.3a INSAT-3D infra-red imagery and U.S Naval Research Laboratory, microwave imagery (Source: www.nrlmry.navy.mil/), ISRO, Thiruvananthapuram, Doppler Weather Radar (DWR) reflectivity product as on the morning of 30th November 2017.

Table-2: Heavy rainfall occurrences (≥ 7cm/day) over Tamil Nadu, Puducherry, Kerala and Lakshadweep during 30 Nov-03 Dec 2017

Date	Rainfall amount (in cm) as on 24-hr ending 0830 IST of date
30.11.2017	TAMIL NADU& PUDUCHERRY: Vallam (Thanjavur), Thuckalay (Kanyakumari), Pondicherry (Puducherry UT) - **7**each KERALA: Aryankavu (Kollam) - **15**
01.12.2017	TAMIL NADU: Papanasam (Tirunelveli)- **45**, Manimutharu (Tirunelveli)- **38**, Mylaudy (Kanyakumari)- **19**, Thenkasi (Tirunelveli)- **17**, Thuckalay (Kanyakumari), Pechiparai (Kanyakumari), Gudalur (Theni), Bhoothapandy (Kanyakumari)- **16** each, Watrap (Virudhunagar)- **15**, Maniyachi (Toothukudi), Eraniel (Kanyakumari), Colachel (Kanyakumari)- **14** each, Nagercoil (Kanyakumari), Kodaikanal (Dindigul), CoonoorPTO (Nilgiris)-**13** each, Kuzhithurai (Kanyakumari), Srivilliputhur (Virudhunagar), Satankulam (Toothukudi), Shencottah (Tirunelveli), Ayikudi (Tirunelveli), Coonoor (Nilgiris), Srivaikuntam (Toothukudi), Samayapuram (Trichy)-**12** each, Ottapadiram (Toothukudi), Tiruchendur (Toothukudi), Kovilpatti AWS (Toothukudi)-**11** each, Tuticorin (Toothukudi), Uttamapalayam (Theni), Ambasamudram (Tirunelveli), Kanyakumari (Kanyakumari)-**10** each, Radhapuram (Tirunelveli), Polur (Tiruvannamalai), Kovilpatti (Toothukudi), Madavaram AWS (Tiruvallur), Sankarankoil (Tirunelveli), Sattur (Virudhunagar)-**9** each, Arani (Tiruvannamalai), Sivaganga (Sivaganga), Sivagiri (Tirunelveli), Uthiramerur (Kancheepuram), Rajapalayam (Virudhunagar), Anna University (Chennai), Uthagamandalam (Nilgiris), Grand anaicut (Thanjavur), Chembarabakkam (Tiruvallur), DGP office (Chennai)-**8** each, Musiri (Trichy), Vadipatti (Madurai), K.paramathi (Karur), Karur (Karur), Anna UniversityARG (Chennai), Vilathikulam (Toothukudi), Lalgudi (Trichy), Ambur (Vellore), Mayanur (Karur), Panchapatti (Karur), Padalur (Perambalur), K bridge (Nilgiris), Thamaraipakkam (Tiruvallur), Cholavaram (Tiruvallur), Periyakulam (Theni), Nanguneri (Tirunelveli), Kalugumalai (Toothukudi), Chennai(N) (Chennai)-**7** each KERALA: Aryankavu (Kollam)-**26**, Myladumpara_ AGRI (Idukki)-**12**, Punalur (Kollam)-**9**, Thiruvananthapuram AP &Neyyattinkara (Thiruvananthapuram)-**8** each. LAKSHADWEEP: Minicoy-**19**
02.12.2017	TAMIL NADU& PUDUCHERRY: Sathanur Dam (Tiruvannamalai)-**23**, Sirkali (Nagapattinam)-**19**, Chidambaram (Cuddalore), Anaikaranchatram (Nagapattinam)-**18** each, Chidambaram AWS (Cuddalore)-**17**, Virudachalam (Cuddalore), Chengam (Tiruvannamalai)-**15** each, Gingee (Villupuram), Mylam AWS (Villupuram), K.m.koil (Cuddalore)-**14** each, Tirukoilur (Villupuram), Vilupuram (Villupuram), CoonoorPTO (Nilgiris), Karaikal (Puducherry UT)-**13** each, Cuddalore (CuddaloreDist), Sethiathope (CuddaloreDist), Tiruvannamalai (TiruvannamalaiDist)-**12** each, Pondicherry (PuducherryUT)-**11**, Mayanur (Karur), Paramathivelur (Namakkal), Polur (Tiruvannamalai)-**10** each, Parangipettai (Cuddalore), Kallakurichi (Villupuram), Kodavasal (Tiruvarur), Nagapattinam

	(Nagapattinam), Vanur (Villupuram), Mayiladuthurai (Nagapattinam), Sankarapuram (Villupuram), Jayamkondam (Ariyalur), Eraniel (Kanyakumari), Neyveli AWS (Cuddalore), Rayakottah (Krishnagiri), Kuzhithurai (Kanyakumari), Ariyalur (Ariyalur), Tindivanam (Villupuram)-**9** each, Tozhudur (Cuddalore), Srimushnam (Cuddalore), Tiruvaiyaru (Thanjavur), Tiruvarur (Tiruvarur), Valangaiman (Tiruvarur), Papanasam (Thanjavur), Ulundurpet (Villupuram), Kothagiri (Nilgiris)-**8** each, Harur (Dharmapuri), Panruti (Cuddalore), Needamangalam (Tiruvarur), Thuckalay (Kanyakumari), Uthangarai (Krishnagiri), Nagercoil (Kanyakumari), Arani (Tiruvannamalai), Attur (Salem)- **7** each KERALA: Thiruvananthapuram AP-**8**, Angadippuram(Malappuram) &Perinthalmanna (Malappuram)-**7** each. LAKSHADWEEP: Minicoy-**14**
03.12.2017	TAMIL NADU& PUDUCHERRY:.Tiruvarur (Tiruvarur)-**14**, Pandavaiyar head (Tiruvarur), Kodavasal (Tiruvarur)-**13** each, Valangaiman (Tiruvarur), Nannilam (Tiruvarur)-**12** each, Nagapattinam (Nagapattinam)-**11**, Needamangalam (Tiruvarur), Kumbakonam (Thanjavur, Karaikal (Puducherry UT)-**9** each, Thiruthuraipoondi (Tiruvarur), Aduthurai AWS (Thanjavur), Tiruvadanai (Ramanathapuram)-**8** each, Thiruvidaimaruthur (Thanjavur)-**7**. KERALA: --- LAKSHADWEEP: ---

Note: Names of districts to which the stations belong is given in brackets.

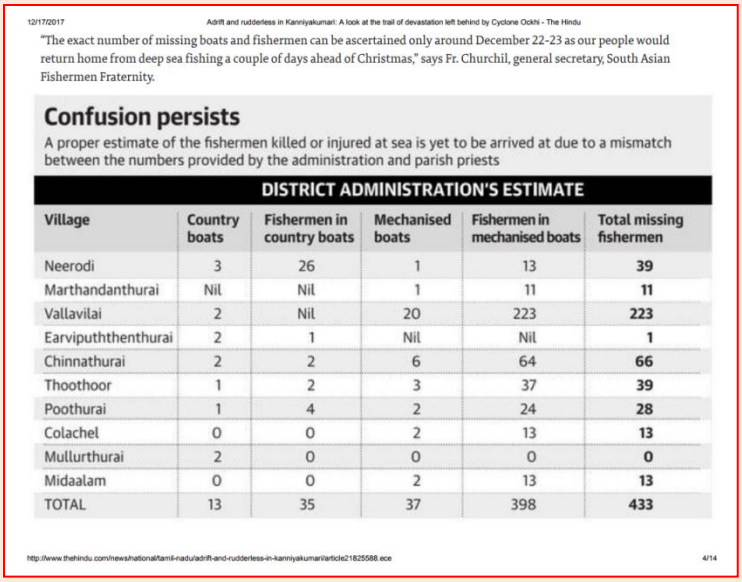
A woman wades through a flooded street in Kanyakumari district's Suchindram. (Photo: PTI)- *Source: The Asian Age dated 02nd Dec 2017*

A washed-away road in Suchindram at flood-hit Kanyakumari. (PTI Photo) – *Source: rediff.com, news dated 1st Dec 2017*

Fig.3b(i) Flooding due to heavy rainfall associated with cyclone Ockhi

Source: IndiaToday.in, New Delhi, 30th Nov 2017

Fig.3b(ii) Damages due to gale winds associated with the passage of cyclone Ockhi over Kanya kumari / Thiruvananthapuram



12/17/2017 Adrift and rudderless in Kanniyakumari: A look at the trail of devastation left behind by Cyclone Ockhi - The Hindu

"The exact number of missing boats and fishermen can be ascertained only around December 22-23 as our people would return home from deep sea fishing a couple of days ahead of Christmas," says Fr. Churchil, general secretary, South Asian Fishermen Fraternity.

Confusion persists

A proper estimate of the fishermen killed or injured at sea is yet to be arrived at due to a mismatch between the numbers provided by the administration and parish priests

DISTRICT ADMINISTRATION'S ESTIMATE

Village	Country boats	Fishermen in country boats	Mechanised boats	Fishermen in mechanised boats	Total missing fishermen
Neerodi	3	26	1	13	**39**
Marthandanthurai	Nil	Nil	1	11	**11**
Vallavilai	2	Nil	20	223	**223**
Earviputhenthurai	2	1	Nil	Nil	**1**
Chinnathurai	2	2	6	64	**66**
Thoothoor	1	2	3	37	**39**
Poothurai	1	4	2	24	**28**
Colachel	0	0	2	13	**13**
Mullurthurai	2	0	0	0	**0**
Midaalam	0	0	2	13	**13**
TOTAL	13	35	37	398	**433**

http://www.thehindu.com/news/national/tamil-nadu/adrift-and-rudderless-in-kanniyakumari/article21825588.ece 4/14

Source: The Hindu dated 17th Dec 2017

12/17/2017 Adrift and rudderless in Kanniyakumari: A look at the trail of devastation left behind by Cyclone Ockhi - The Hindu

DECEMBER 17, 2017 07:41 IST
UPDATED: DECEMBER 17, 2017 14:06 IST

A litre of packaged drinking water was sold at □40 and a candle at □25. When the demand for generators increased sharply as the district plunged into darkness, □600 was charged for hiring a generator for 30 minutes just to pump water from wells to overhead tanks.

The damage inflicted by Cyclone Ockhi affected all aspects of life

Houses	5032	Electric poles	13450
No. of villages hit by drinking water shortage	1155	No. of Panchayats hit by drinking water shortage	95
Area under paddy prior to Ockhi (in hectares)	4284	Hectares of paddy damaged	299
No. of coconut trees uprooted	13150	No. villages with such uprooted trees	144
Power cables	802 kms	Rubber trees	5.63 lakh
Banana trees	48.15 lakh	Trees uprooted on govt. land	11299
Trees uprooted along the road	175	Damage to horticultural crops (in hectares)	3623
Primary school buildings	18	Middle school buildings	9
Panchayat, panchayat union roads damaged	192.23 kms	State highways	9.8 kms
Important roads	11.9 kms	Other roads	53.34 kms

As many as 178 persons from the Kaani tribe in Western Ghats affected

However, by all accounts, it was the fate of the fishermen that was by far the worst. Confusion prevailed for more than a week over fixing the number of missing boats, even as the fisherfolk protested against the delay in launching search operations deep sea.

Source: The Hindu dated 17 Dec 2017

Fig.3b(iii) Media reports on the damages due cyclone Ockhi

(v) ***Deep depression over BOB (06-09 Dec):*** A LOPAR formed over Malay Peninsula and adjoining Andaman Sea in the morning of 30thNov, 2017. It lay as a WML over south Andaman Sea on 1stDec, over Sumatra coast and adjoining south Andaman Sea on 2ndDec, over southeast BOB & adjoining south Andaman Sea and equatorial Indian Ocean on 3rdand 4thand over southeast BOB & neighbourhood on 5th. It concentrated into a D over southeast BOB & neighbourhood in the morning of 6thDec. It moved northwards till early hours of 8thDec. Thereafter, it moved north-northwestwards and intensified into a DD in the early morning of 8th over central BOB. Moving nearly northwards, it weakened into D during the night of same day over westcentral BOB. It started moving north-northeastwards from morning of 9thand weakened into a WML over northwest BOB in the evening of 9thDec and into a LOPAR over north BOB & neighbourhood in the evening of 10th Dec.

4. Seasonal rainfall performance during NEM 2017

The northeast monsoon performance during 2017 was *normal* (-19% to +19%) over 4 subdivisions benefitted by the NEM (TN, KER, RYS and SIK) and *deficient* (-20% to -59%) over the other subdivision, CAP (-48%). Fig.4 and Table-3 presents the season ending (01st Oct-31st Dec) rainfall figures over these subdivisions. Even though four subdivisions recorded *normal* seasonal rainfall, three (TN: -9%, KER: -8% & SIK: -5%) were on the negative side of the normal range. RYS was the lone subdivision that recorded positive rainfall departure of +19% during the season.

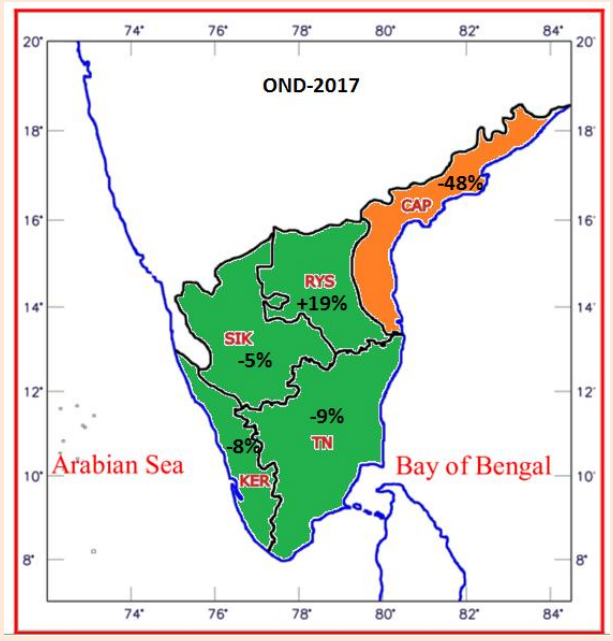


Fig.4 Seasonal rainfall performance of NEM 2017 over the five meteorological subdivisions benefitted by the NEM

Table-3: Sub divisional seasonal rainfall during October-December 2017

Subdivision	01st October – 31st December 2017		
	Actual (mm)	Normal (mm)	PDN (%)
TN	401.0	442.0	-9
KER	441.8	480.7	-8
CAP	171.6	327.4	-48
RYS	261.8	219.2	19
SIK	199.9	209.6	-5

PDN: Percentage Departure from Normal
TN: Tamil Nadu &Puducherry; KER: Kerala;
CAP: Coastal Andhra Pradesh; RYS: Rayalaseema; SIK: South Interior Karnataka

Legend:

Largely Deficient	*Deficient*	*Normal*	*Excess*	*Large Excess*
≤ -60%	-20% to -59%	-19% to +19%	+20% to +59%	≥+60%

Month-wise rainfall statistics are presented in Table-4. Tables-5a&b depict the week by week performance (weekly & cumulative), Table-6a&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 ≥ 7cm/day***;*** ***Very Heavy*** rainfall ≥ 12cm/day; ***Extremely Heavy*** rainfall ≥ 21 cm/day).

Table-4: Subdivisional monthly rainfall during NEM 2017

Subdivision	OCT			NOV			DEC		
	Actual (mm)	Normal (mm)	PDN (%)	Actual (mm)	Normal (mm)	PDN (%)	Actual (mm)	Normal (mm)	PDN (%)
TN	157.4	181.1	-13	144.8	171.7	-16	98.8	89.2	11
KER	228.0	292.4	-22	152.3	150.9	1	61.4	37.4	64
CAP	123.8	193.2	-36	46.6	106.6	-56	1.2	27.6	-96
RYS	221.1	129.4	71	33.3	66.1	-50	7.4	23.7	-69
SIK	178.6	147.7	21	13.9	49.2	-72	7.8	12.7	-39

.(TN, KER, CAP, RYS, SIK and Legend: same as Table-3)

Table-5a: Week by week rainfall departures (%) during NEM 2017

Subdivision	04/10/2017	11/10/2017	18/10/2017	25/10/2017	01/11/2017	08/11/2017	15/11/2017	22/11/2017	29/11/2017	06/12/2017	13/12/2017	20/12/2017	27/12/2017
TN	-6	64	-31	-77	18	27	-63	-66	-14	231	-81	-81	-84
KER	-34	-30	33	-71	-11	15	-15	2	-5	265	-44	34	-99
CAP	-18	15	-40	-75	-70	-39	-70	-49	-98	-79	-99	-99	-100
RYS	142	179	144	-96	-51	12	-89	-88	-99	-6	-99	-100	-99
SIK	85	84	111	-95	-86	-29	-99	-72	-99	84	-94	-85	-100

Table-5b: Weekly cumulative rainfall departures (%) during NEM 2017

Subdivision	04/10/2017	11/10/2017	18/10/2017	25/10/2017	01/11/2017	08/11/2017	15/11/2017	22/11/2017	29/11/2017	06/12/2017	13/12/2017	20/12/2017	27/12/2017
TN	-6	39	10	-19	-11	-2	-11	-17	-17	3	-3	-6	-8
KER	-34	-31	-6	-24	-22	-16	-16	-15	-15	-7	-8	-8	-8
CAP	-18	5	-11	-28	-36	-36	-39	-40	-43	-44	-46	-47	-47
RYS	142	165	159	96	59	61	46	37	30	28	23	21	20
SIK	85	73	83	42	19	14	14	2	2	0	-2	-3	-4

TN, KER, CAP, RYS, SIK: same as Table-3

Legend:

Largely Deficient	*Deficient*	*Normal*	*Excess*	*Large Excess*
≤ -60%	-20% to -59%	-19% to +19%	+20% to +59%	≥+60%

Table-6a: Spatial rainfall distribution

Subdivision	No. of days				
	WD	FWD	SCT	ISOL	DRY
TN	4	12	24	44	8
KER	11	17	12	33	19
CAP	0	5	12	43	32
RYS	3	8	9	30	42
SIK	6	11	7	26	42

WD: ***Widespread***
(76-100% of stations reporting rainfall)
FWD : Fairly widespread
(51-75% of stations reporting rainfall)
SCT: Scattered
(26-50% of stations reporting rainfall)
ISOL: Isolated
(≤25% of stations reporting rainfall)
DRY: No rain

Table-6b: Frequencies of active and vigorous monsoon days and heavy rainfall days

Subdivision	No. of days				
	Activity		Heavy Rainfall		
	Vigorous	Active	Extremely Heavy	Very Heavy	Heavy
TN	3	8	4	14	46
KER	3	11	1	9	22
CAP	0	2	0	5	19
RYS	4	7	0	6	16
SIK	1	8	0	4	12

Active: Fairly widespread to widespread subdivisional 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 subdivisional 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

The monthly and weekly rainfall figures indicate that rainfall during the extended southwest monsoon regime prior to the onset of NEM on 27th October has been significant over RYS, SIK and CAP. Major portion of the total seasonal rainfall realized over these three subdivisions was during the first 2-3 weeks of October. SIK and RYS recorded *excess* to *large*

excess rainfall in the month of October with SIK receiving 18 cm of rainfall in October out of its seasonal total of 20 cm. Even TN, which normally does not benefit much from the southwest monsoon, came under normal category at the end of October despite the late onset of NEM. However, CAP and KER ended up deficient in October. In November and December, TN and KER received *normal – large excess* rainfall, but the other three subdivisions came under *deficient- largely deficient* category.

Subsequent to the onset of NEM on 27th October, rainfall during the first two weeks, (week ending 01.11.2017 & 08.11.2017) and the week ending 06.12.2017 were the major contributions to the seasonal total. Whereas the rainfall during the last week of October and the first week of November was associated with upper air cyclonic circulations off TN and KER coasts and formation of low pressure areas close the TN coast, rainfall during week ending 06th Dec (30th Nov- 06th Dec) was associated with the passage of cyclone Ockhi over the Comorin area and Arabian sea during the period 29th Nov – 03rd Dec.

In the daily scale, there have been 40 days (each) of *SCT-WD* rainfall activity over TN and KER with 11 days and 14 days respectively of active to vigorous monsoon conditions. RYS and SIK experienced 20-24 days of *SCT-WD* rainfall activity of which 16-18 days were in October. There were only 17 days of *SCT-FWD* rainfall activity over CAP and during the rest of the 75 days, only *isolated* rain – *dry* conditions prevailed over the subdivision. Regarding frequency of heavy rainfall days, TN reported maximum of 46 days of *heavy* rainfall activity with 14 days of *very heavy* rain and 4 days of *extremely heavy* rain and Kerala reported 22, 9 and 1 days of *heavy*, *very heavy* and *extremely heavy* rainfall.

5. Performance of NEM 2017 over Tamil Nadu and Puducherry

Spatial and temporal rainfall distributions over the TN subdivision during Oct-Dec 2017 are depicted by means of district-wise rainfall distribution and area averaged daily rainfall distribution over TN. Fig.5 presents the daily rainfall distribution over the TN subdivision (including the state of Tamil Nadu and UT of Puducherry) during Oct-Dec 2017. The daily subdivisional rainfall was above normal on 8 days before the NEM onset and on 15 days after the onset.

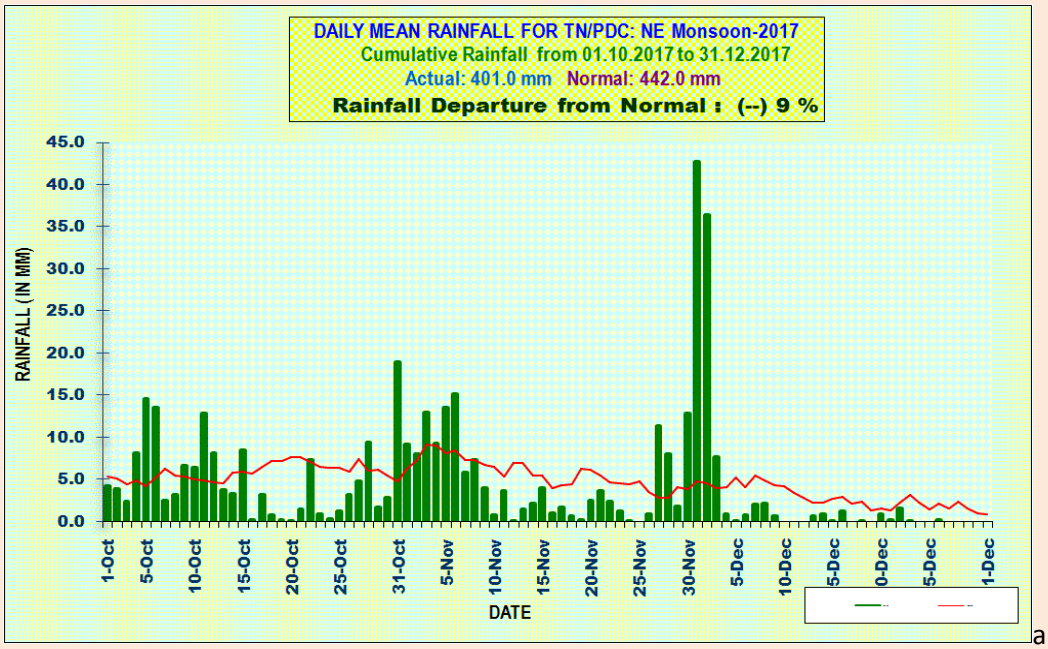


Fig.5 Area averaged daily rainfall over TN subdivision during Oct-Dec 2017

District-wise rainfall realised is presented in Table-7 and Fig.6. As seen, 3 districts – Kanyakumari, Tirunelveli and Nagapattinam received excess rainfall during the season. 16 districts came under normal category and 15 districts ended up deficient at the end of the season. Tirunelveli was the most benefitted district with 42% excess rainfall and Pudukottai was the worst affected district with 49% deficient rainfall.

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 2017, SPI indicated dry conditions over most parts of northwest TN and south TN and mildly wet conditions over the northeastern districts of TN and the extreme south coastal districts of Kanyakumari and Tirunelveli (Fig.7). Regarding the other subdivisions of the region, most parts of CAP, north Kerala and western districts of SIK came under dry categories and the rest of the subdivisions ended up mildly wet at the end of the season.

Table-7: District-wise rainfall figures of Tamil Nadu and Puducherry during Oct-Dec 2017

State/District/Subdivision	Actual rainfall (mm)	Normal rainfall (mm)	Percentage departure from normal
STATES			
Puducherry (UT)	980.7	915.6	7
Tamil Nadu	399.0	440.4	-9
DISTRICTS			
ARIYALUR	491.8	545.5	-10
CHENNAI	937.8	789.9	19
COIMBATORE	182.5	328.9	-45
CUDDALORE	775.8	697.8	11
DHARMAPURI	254.7	330.1	-23
DINDIGUL	325.1	436.4	-25
ERODE	196.4	314.6	-38
KANCHEEPURAM	672.5	641.8	5
KANYAKUMARI	611.2	496.4	23
KARAIKAL	1197.0	1048.5	14
KARUR	234.3	314.7	-26
KRISHNAGIRI	329.7	289.4	14
MADURAI	286.5	419.1	-32
NAGAPATTINAM	1132.3	941.0	20
NAMAKKAL	256.6	291.6	-12
NILGIRIS	350.3	478.2	-27
PERAMBALUR	306.8	440.9	-30
PUDUCHERRY	862.6	843.1	2
PUDUKKOTTAI	207.5	406.2	-49
RAMANATHAPURAM	259.1	491.7	-47
SALEM	341.9	370.5	-8
SIVAGANGA	259.2	422.7	-39
THANJAVUR	433.7	550.3	-21
THENI	280.7	357.9	-22
TIRUNELVELI	665.4	467.2	42
TIRUPPUR	255.6	314.3	-19
TIRUVALLUR	677.9	589.3	15
TIRUVANNAMALAI	524.9	446.5	18
TIRUVARUR	701.8	719.1	-2
TOOTHUKUDI	353.6	427.0	-17
TRICHY	223.7	391.5	-43
VELLORE	338.8	348.7	-3
VILLUPURAM	535.7	499.1	7
VIRUDHUNAGAR	332.3	419.0	-21
TN Subdivision	401.0	442.0	-9

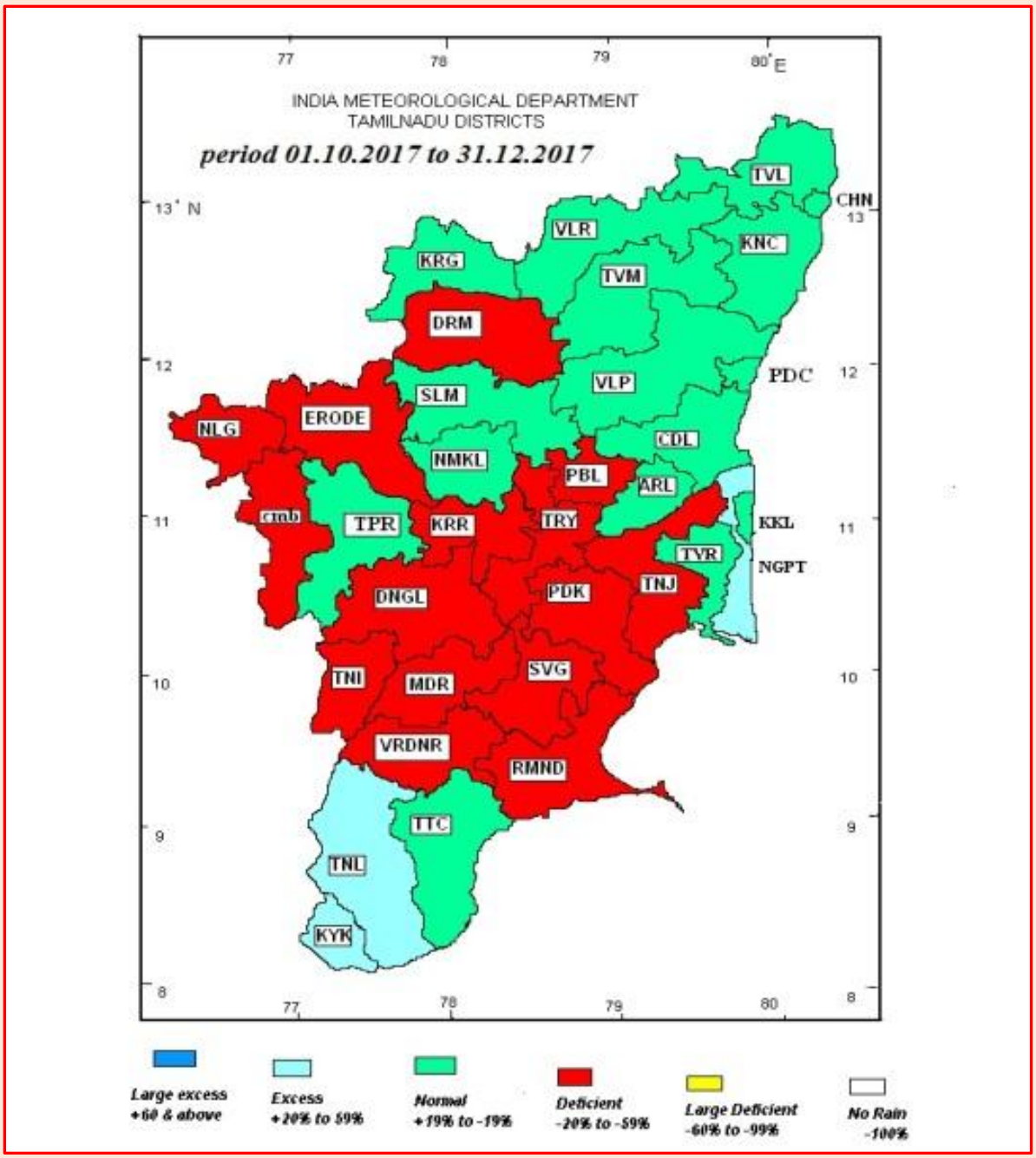


Fig.6 District-wise rainfall distribution over the TN subdivision during Oct-Dec 2017

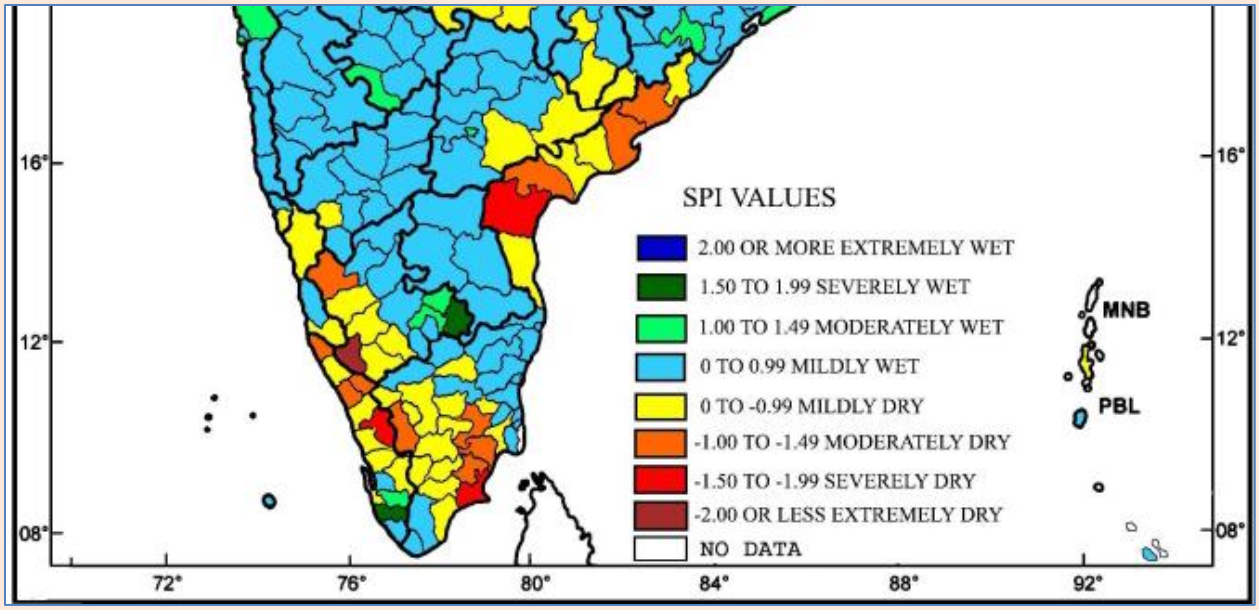


Fig.7 Standardised Precipitation Index for October-December 2017 over the southern peninsular India.

7. Chief circulation features

(a) ***Synoptic scale features:*** The mean and anomalous wind pattern over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during October –December 2017 (Fig.8a-c) indicate the following: In the lower tropospheric levels (850 hPa), two anomalous cyclonic circulations, one over the southeast Arabian Sea off Kerala coast and another over the westcentral Bay of Bengal and adjoining region in October, an anomalous east west trough over the Equatorial Indian Ocean in November, an anomalous cyclonic circulation over the south, central Arabian sea and adjoining areas in December. In the mid-upper levels (500 & 250 hPa levels), an anomalous anticyclonic circulation was observed at 500 hPa during all three months of the season. In October, it was observed over the northwestern parts of India and adjoining region and extended upto 250 hPa level; in November, it was seen over most parts of the country at 500 hPa and anomalous westerlies prevailed at 250 hPa level; in December, at 500 hPa, anticyclonic circulation was observed over the northeastern parts of India and adjoining Bay of Bengal which extended upto upper tropospheric levels.

(b) ***Large scale features****:* Based on the reports of various global climate monitoring centres, it was noted that during October-December 2018, neutral ENSO to weak La Nina conditions prevailed over the equatorial Pacific region. Indian Ocean Dipole was normal and on the negative side. Both these major climate indices were not favourable for NEM activity during 2017. MJO was more active over the Pacific and the Atlantic region and hence did not contribute significantly to NEM 2017 over the Indian region.

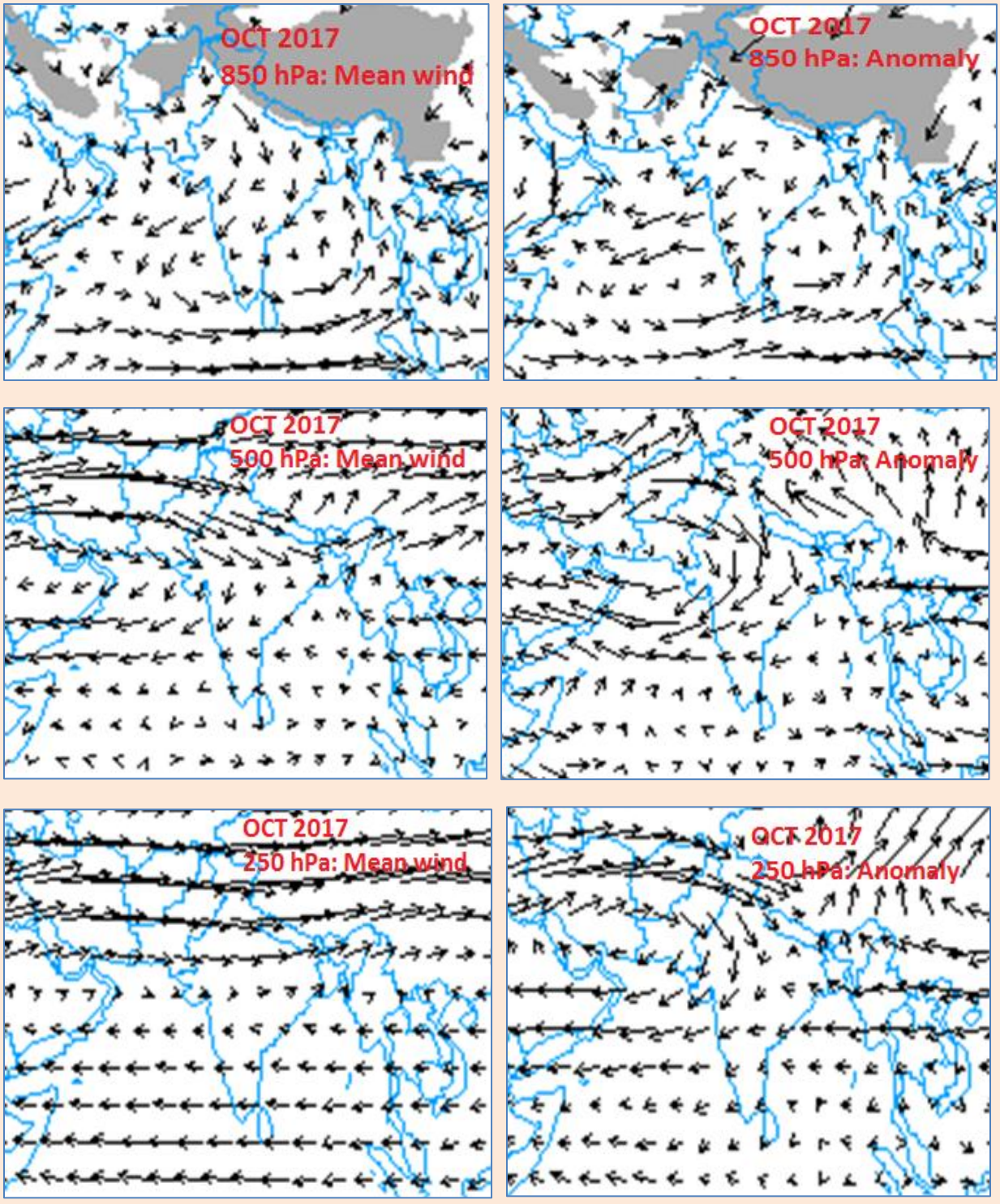


Fig.8a Mean and anomalous wind pattern over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during October 2017 (Source: Climate Diagnostic Bulletin of India, IMD Pune)

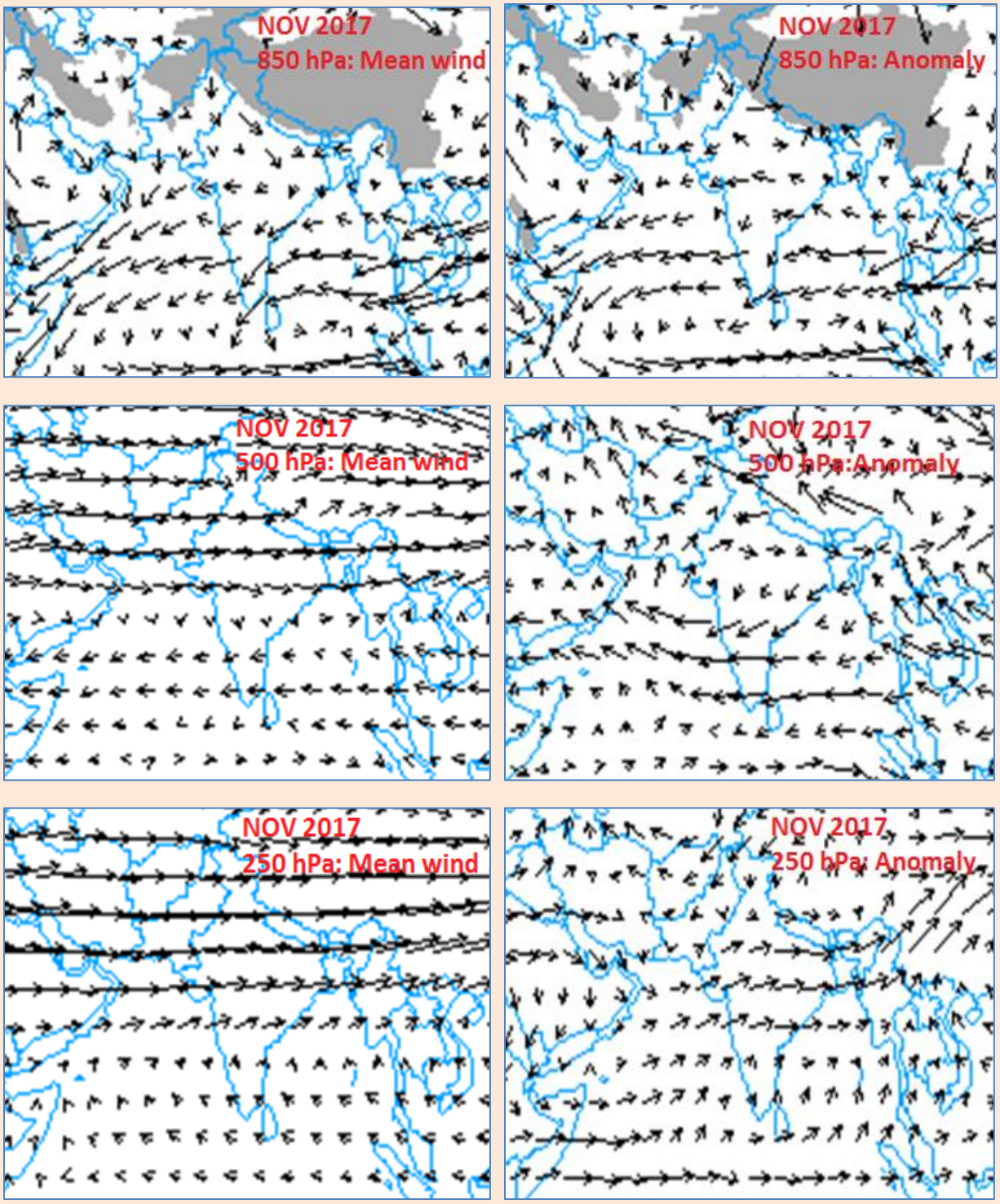


Fig.8b Mean and anomalous wind pattern over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during November 2017 (Source: Climate Diagnostic Bulletin of India, IMD Pune)

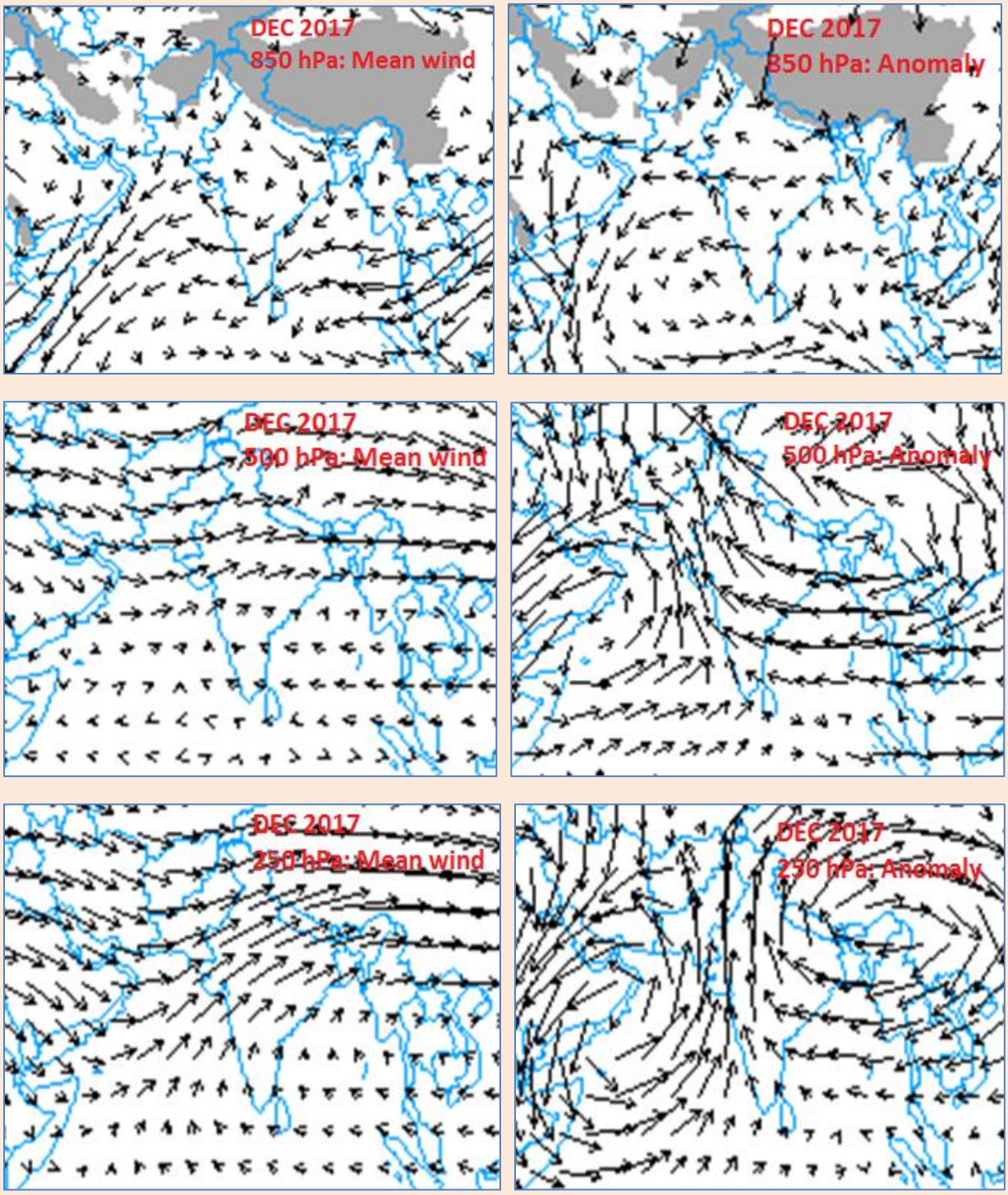


Fig.8c Mean and anomalous wind pattern over the Indian region at 850 hPa, 500 hPa and 250 hPa levels during December 2017 (Source: Climate Diagnostic Bulletin of India, IMD Pune)

8. Summary

The onset of NEM 2017 over the southeastern parts of peninsular India took place on 27th October. Four subdivisions (Tamilnadu, Kerala, Rayalaseema and South Interior Karnataka) received normal rainfall during the season. Coastal Andhra Pradesh ended up deficient at the end of the season. Whereas TN and KER received normal to excess rainfall in November and December, the other three subdivisions benefitted mainly from the extended southwest monsoon rainfall in October prior to the onset of NEM. Tropical cyclone Ockhi during 29 Nov to 06 Dec caused extensive rainfall activity and severe damages over south Tamil Nadu, Kerala and Lakshadweep.

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 Thirvananthapuram 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.

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 subdivisional 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 subdivisional 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.