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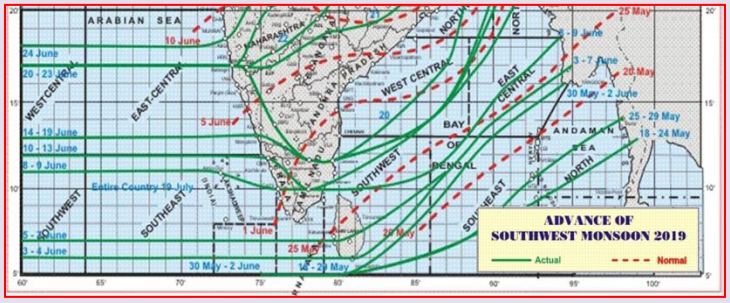
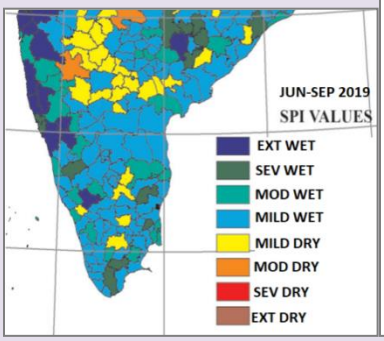
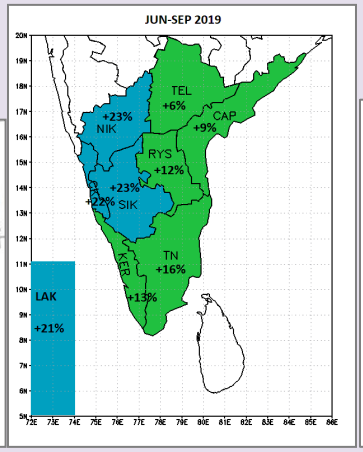
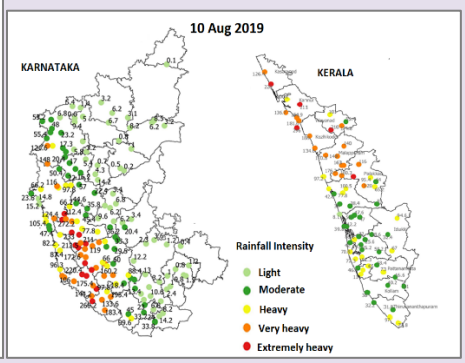
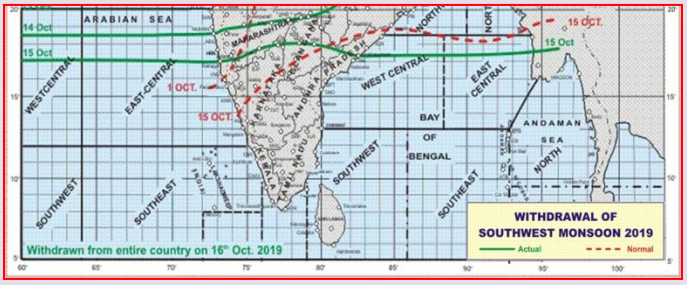
SOUTHERN PENINSULAR INDIA:
SOUTHWEST MONSOON, 2019 - REPORT











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HIGHLIGHTS

✓ During 2019, southwest monsoon (SWM) advanced over Andaman Sea on 24th May. It gradually covered some more parts of Bay of Bengal, some parts of south Arabian Sea, Maldives-Comorin-Lakshadweep area and advanced over some parts of Kerala and south Tamil Nadu on 08th June. Thus, the onset of the monsoon over Kerala took place on 08th June, 7 days later than the normal date of 1st June and covered the entire southern peninsular India (SP) by 22ndJune. It covered the entire country on 19th July.

✓ Rainfall during the SWM season of June-September 2019 over the southern Indian peninsular region comprising of the five states of Andhra Pradesh, Telangana, Karnataka, Kerala and Tamil Nadu and two union territories of Puducherry and Lakshadweep was 840.9 mm which is 15.8% more than its long period average (LPA) of 726.2 mm. The SWM seasonal rainfall over the country as a whole was110% of its LPA.

✓ Seasonal rainfall over the nine meteorological subdivisions covering the five states and two union territories in the region was excess in four sub divisions[Coastal Karnataka (CK), North Interior Karnataka (NIK), South Interior Karnataka (SIK) and Lakshadweep (LAK)], and normal in 5 sub divisions – Kerala and Mahe(KER), Tamil Nadu, Puducherry and Karaikal(TN), Coastal Andhra Pradesh and Yanam(CAP), Rayalaseema (RYS) and Telangana (TEL). The seasonal rainfall figures over the nine subdivisions - CAP, RYS, TEL, TN, CK, NIK, SIK, KER and LAK were +9%, +12%, +6%, +16%, +22%, +23%, +23%, +13%, and +21% respectively.

✓ Under the influence of stronger than normal southwesterlies in the lower-mid tropospheric levels over the peninsular region coupled with orographic effect recurrent heavy rainfall activity occurred over Kerala, Karnataka and adjoining hilly regions of Tamil Nadu in the second week of August causing inland flooding in many areas.

✓ The withdrawal of SWM 2019 commenced from the northwest India on 09th October only, a delay by more than a month (normal date – 1st September). The monsoon withdrew from the SP region during 15th-16th October 2019. It withdrew from the entire country on 16th October with the simultaneous commencement of northeast monsoon rains over Tamil Nadu, Kerala and adjoining areas of Andhra Pradesh and Karnataka on 16th October 2019.

1. Onset and Advance

During the year 2019, the Bay of Bengal (BOB) branch of southwest monsoon (SWM) current advanced into the BOB with the characteristic strengthening and deepening of cross equatorial flow and enhanced cloudiness and rainfall over the south Andaman Sea, and some parts of south BOB on 24th May. The Arabian Sea (AS) branch of the SWM current, which leads to the onset of SWM over Kerala, advanced over parts of Kerala and south Tamil Nadu on 08thJune 2019, 7 days later than the normal date of onset over Kerala on 1st June. Subsequently, it advanced gradually into other parts of India. It covered the entire southern peninsular India (SP) comprising of five states (Andhra Pradesh, Telangana, Kerala, Karnataka and Tamil Nadu) and two union territories (Puducherry and Lakshadweep) - divided into nine meteorological subdivisions of Coastal Andhra Pradesh and Yanam(CAP), Telangana (TEL), Rayalaseema (RYS), Tamil Nadu, Puducherry and Karaikal (TN), Coastal Karnataka (CK),North Interior Karnataka (NIK), South Interior Karnataka (SIK), Kerala and Mahe(KER) and Lakshadweep (LAK) -by 22ndJune against the normal date of 10th June.

On 08th June, when the monsoon onset took place over Kerala, the northern limit of the monsoon (NLM) passed over Aminidivi, Kochi and Madurai. On 10th, it further advanced into most parts of Kerala and some more parts of Tamil Nadu. On 14th, it covered entire Kerala and advanced into some parts of CK, SIK and some more parts of TN. Subsequently, its further advance over the SP region took place only on 20th June when it covered the entire CK, some more parts of SIK, TN and some parts of RYS and NIK. However, it advanced over the remaining parts of RYS, some more parts of NIK, some parts of TEL and the entire CAP on 21st. On 22nd, it advanced into the remaining parts of NIK and TEL and covered the entire SP region on 22nd June. Fig.1a depicts the progression of the northern limit of monsoon over the region.

During the onset phase of the monsoon over Kerala, on 06th June, an east-west shear zone ran roughly along Lat. 8°N between 3.1 & 3.6 km above mean sea level across Lakshadweep - Maldives - Comorin area and it is gradually shifted northwards. Westerly/southwesterly wind over south Arabian Sea strengthened and deepened upto 600 hPa level by 8th June. An off shore trough also developed on the 8th June off south Maharashtra - Kerala coast. Under the influence of these favourable conditions, scattered to widespread rainfall occurred over KER, CK, SIK and

LAK from 06th June onwards leading to the onset of the monsoon over parts of Kerala and south Tamil Nadu on 08th June.

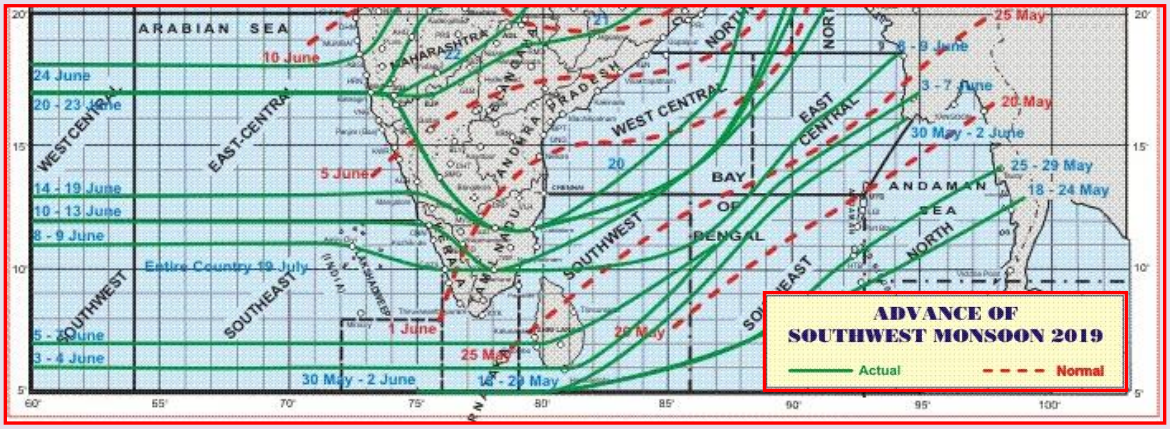


Fig.1a: Advance of southwest monsoon 2019 over southern peninsular India depicted by lines of northern limit of monsoon on various dates

Isobaric analysis at surface level indicating the offshore trough off Kerala-south Maharashtra coast and streamline analysis at lower-mid tropospheric levels indicating cyclonic circulation in the lower-mid levels over LAK area, off Kerala coast as on 8th June / 0830 IST are presented in **Fig.1b**. Under the influence of this cyclonic circulation extending up to 4.5 km, a low pressure area formed over the southeast Arabian Sea and adjoining LAK and east central Arabian Sea on 09th June. It concentrated into a depression on 10th June and moved nearly northward - north-northwestward and gradually intensified into **very severe cyclonic storm VAYU** off Gujarat coast. Moving northwestwards for some time it started weakening and re-curved northeastwards towards Gujarat coast. Under its influence, the advance of the monsoon over the SP region was delayed. Intense heating and sweeping away of moisture leading to cloud free conditions over many areas led to severe heat wave / heat wave conditions over pockets of CAP, TEL, RYS and North TN during this phase. On 7th and 8th June, Adilabad (TEL) recorded highest maximum temperature of 46°C in the region. Highest maximum temperature of 42-44°C were recorded in the region almost on all the days during the period 09th-21stJune. However, there were isolated convective activity over some areas during this period.Fig.1c presents the INSAT-3D satellite imageries depicting the cloudiness associated with the onset of SWM over Kerala on 08th June and its further advance into the SP region by 22nd June 2019. Fig.1d presents

the IMD gridded rainfall depicting the advance of SWM 2019 over the SP region and Fig.1e depicts the gauge observed rainfall over Kerala during 06-08 June 2019.

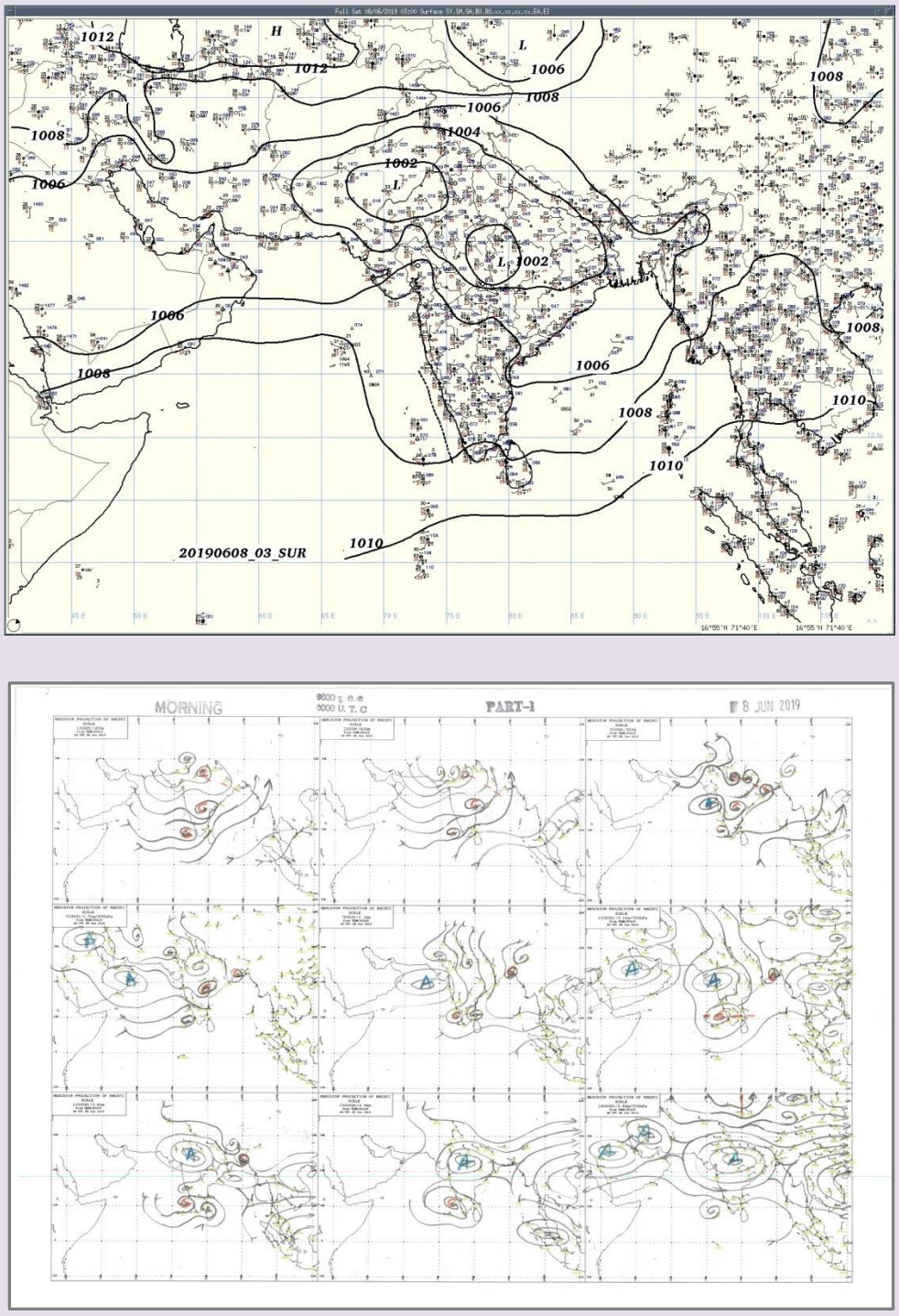


Fig.1b: Isobaric analysis at surface level and streamline analysis at lower-mid tropospheric levels as on 08th June 2019 / 0830 IST

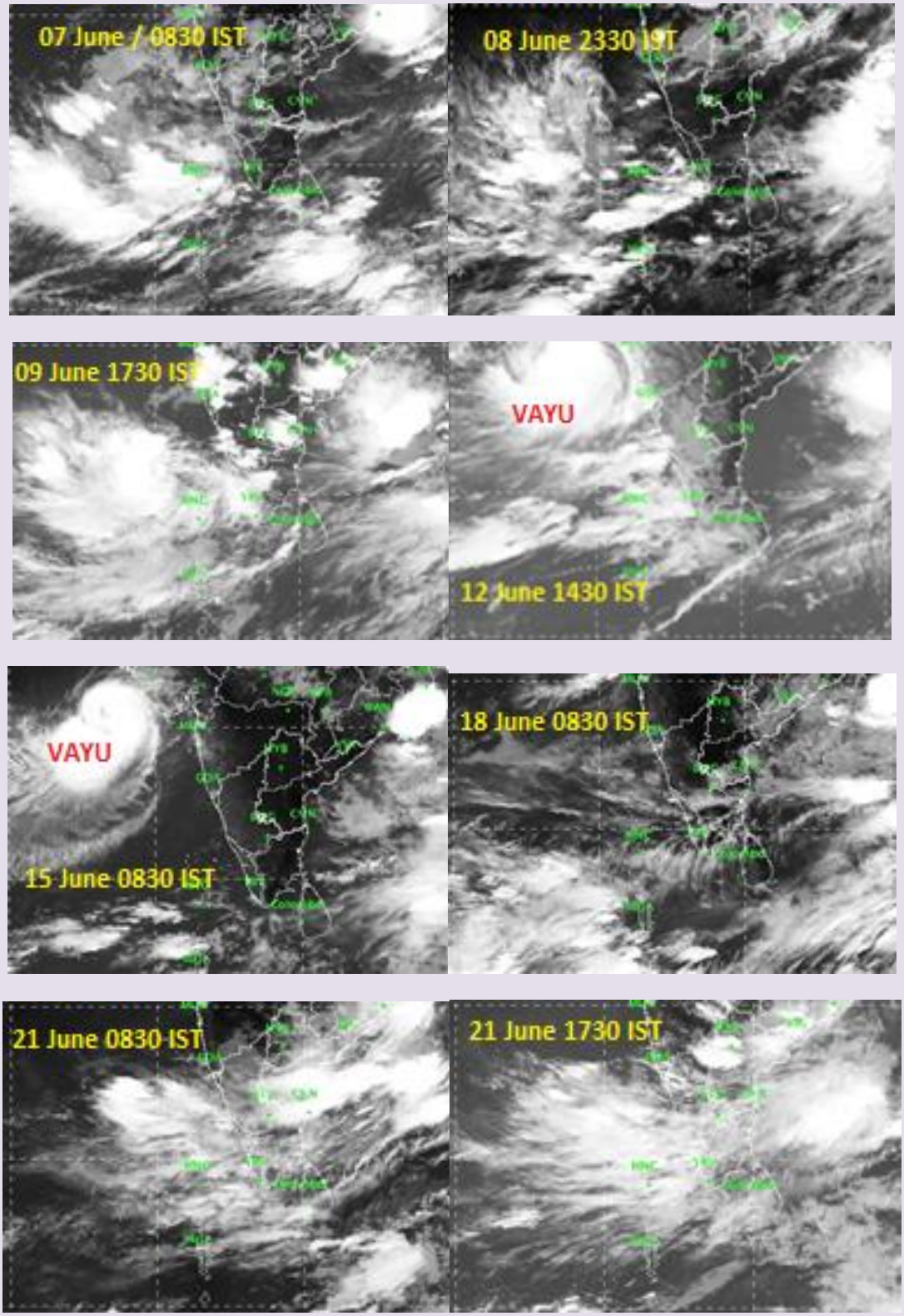


Fig.1c: INSAT-3D infra-red imageries as on 07/0830, 08/2330, 09/1730, 12/1430, 15/0830, 18/0830, 21/0830 and 21/1730 IST of June 2019 depicting the advance of SWM 2019 over the SP region

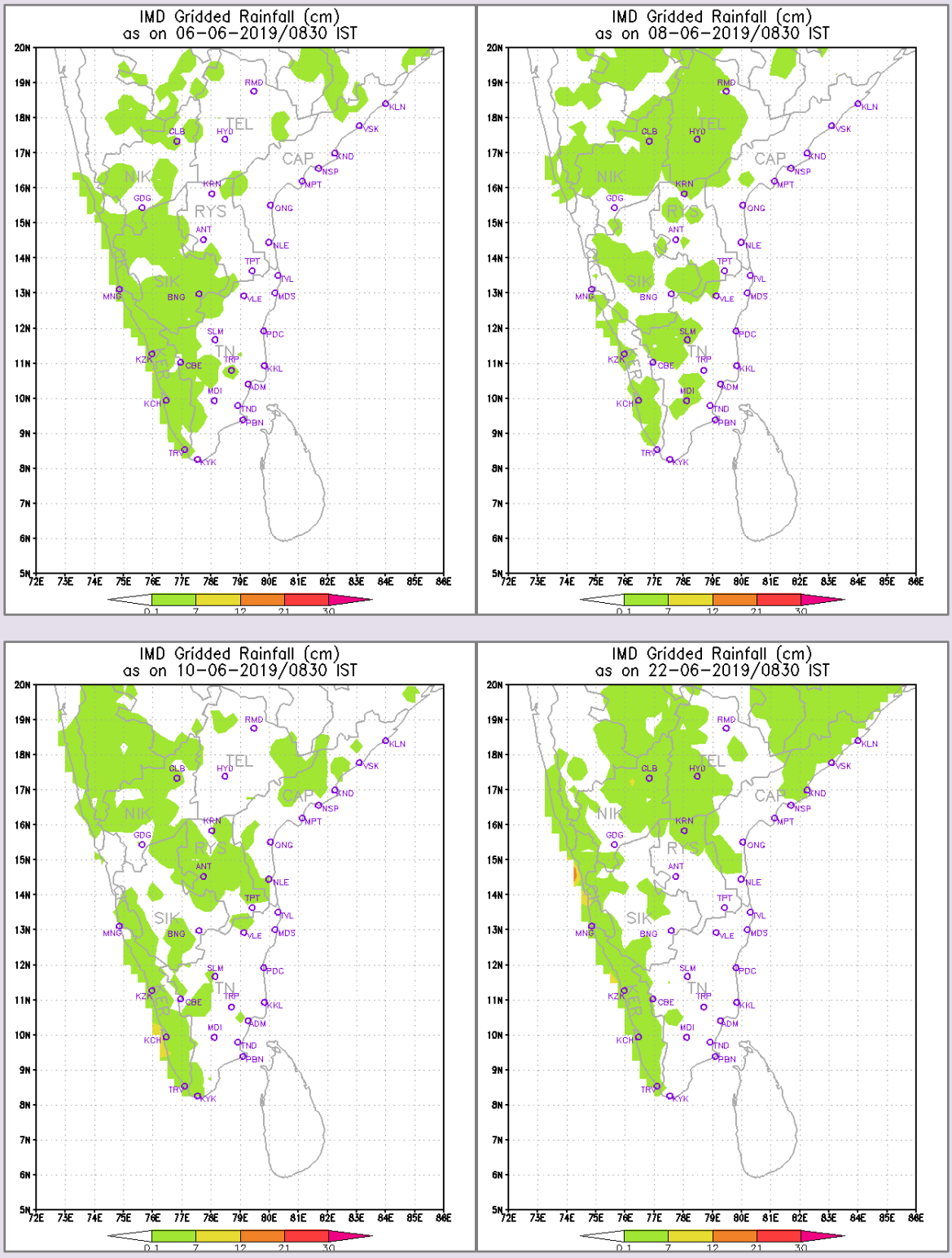


Fig.1d: IMD gridded rainfall in cm as on 24-hr ending 0830 IST of 06th, 08th, 10th and 22nd June 2019 depicting the advance of monsoon rains over the SP region during SWM 2019.

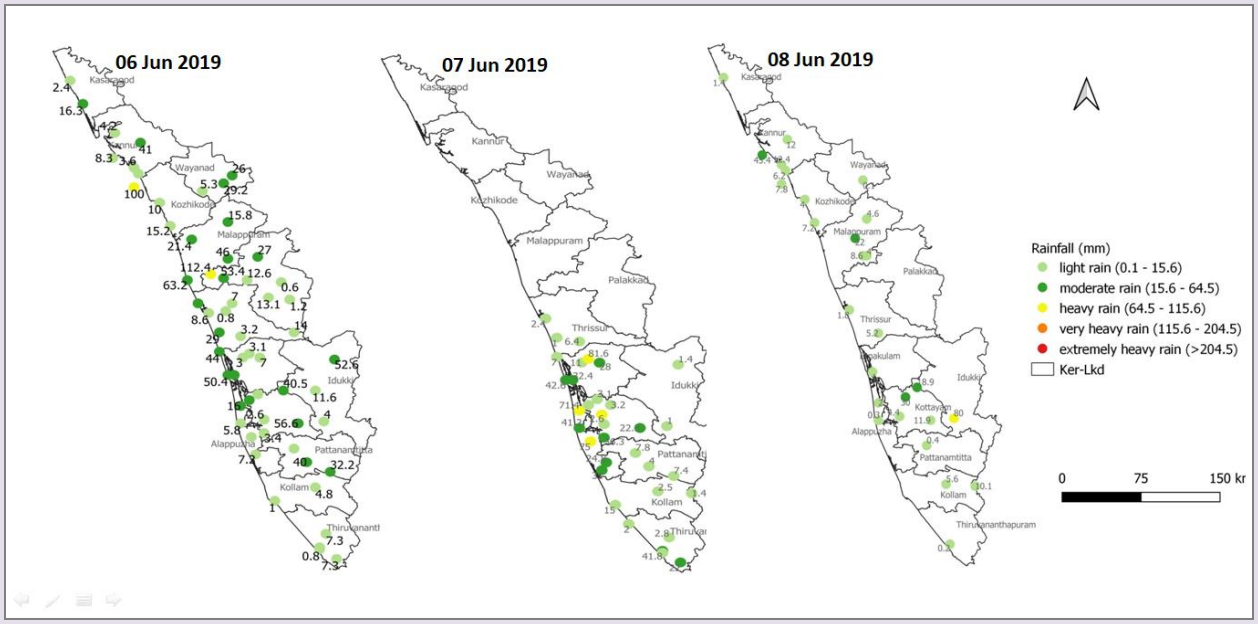


Fig.1e: Rainfall over Kerala as on 24-hr ending 0830 IST of 6th, 7th and 8th June 2019

2. Rainfall distribution

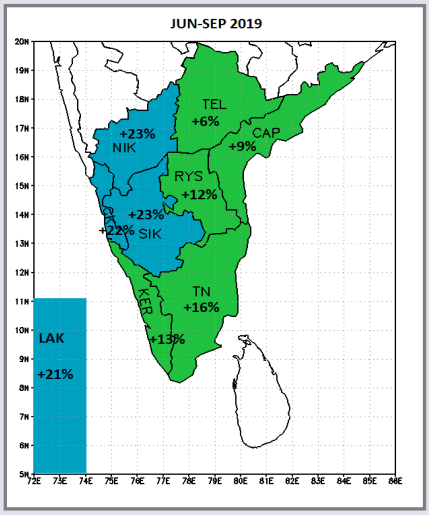
2.1 Seasonal sub divisional rainfall

The SWM seasonal rainfall (June-September) during 2019 over the country as a whole was110 of its long period average (LPA) and that over the SP region was 115.8% of LPA. The spatial rainfall distribution over the country is determined in terms of percentage departure from normal (PDN) over 36 meteorological subdivisions. As per IMD's classification of monsoon performance over a meteorological subdivision, if the amount of rainfall received over a region (expressed as PDN) is between -19% and +19%, the monsoon performance is termed as *normal*. If the PDN is between -20% and -59%, the region comes under *deficient* category, if PDN is less than or equal to -60%, the region falls under *scanty* category, PDN of +20% to +59% indicates *excess* rainfall category and if the PDN is greater than or equal to +60%, it is termed as *large excess*. During SWM 2019, in the SP region, four sub divisions - LAK, CK, SIK and NIK received *excess* rainfall, five subdivisions (KER, CAP, TEL, TN&RYS) received *normal* rainfall with all the sub divisions recording greater seasonal total rainfall than their respective seasonal

normal. The cumulative seasonal (01st June to 30th Sep) rainfall figures for the nine meteorological sub divisions of the SP region are furnished in Table-1 and Fig.2.

Table-1: Seasonal sub divisional rainfall distribution over the SP region during the SWM season, 2019 (01st June-30 Sep 2019)

SUB-DIVISION	Actual rainfall (mm)	Normal rainfall (mm)	Percentage departure from normal (%)
COASTAL AP & YANAM (CAP)	641.5	586.9	9%
TELENGANA (TEL)	805.6	759.6	6%
RAYALASEEMA (RYS)	460.0	411.6	12%
TAMILNADU, PDC and KKL (TN)	396.7	342.0	16%
COASTAL KARNATAKA (CK)	3787.7	3098.9	22%
NORTH INTERIOR KARNATAKA (NIK)	611.6	497.1	23%
SOUTH INTERIOR KARNATAKA (SIK)	839.1	681.8	23%
KERALA & MAHE (KER)	2309.9	2049.2	13%
LAKSHADWEEP (LAK)	1227.0	1013.1	21%



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

Fig.2: Sub divisional seasonal rainfall (percentage departures from normal) during Jun-Sep 2019 over the SP region

2.2 Monthly sub divisional rainfall

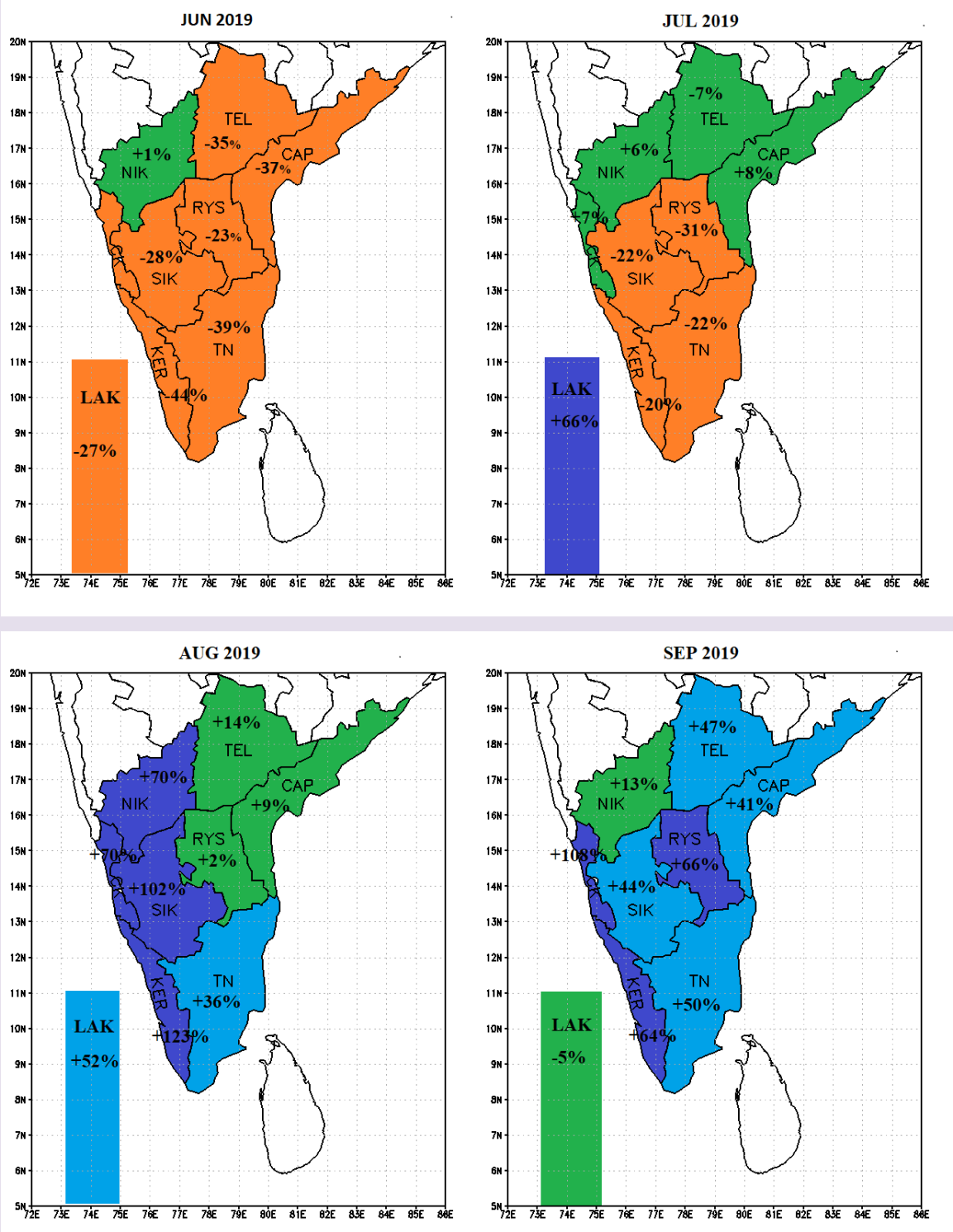
The monthly sub divisional rainfall scenario is presented in Table-2 and Fig.3. During the SWM 2019, the subdivision of NIK received *normal* to *large excess* rainfall during all the four months of the season. In June, except NIK that received *normal* rainfall, all other sub divisions in the SP region came under *deficient* category. In July, LAK received *large excess* rainfall of +66% and the northern parts of the SP region covring CAP, TEL, NIK and CK came under *normal* category (-7 to +8%). However, KER, SIK, TN and RYS continued to be *deficient*. In August, excepting CAP, RYS and TEL that received *normal* rainfall, other sub divisions in the SP region received *excess* to *large excess* rainfall. KER and SIK recorded 123% and 102% excess rainfall. In September, excepting NIK and LAK that received *normal* rainfall, the other sub divisions in the region received *excess* to *large excess* rainfall. CK recorded 108 % excess rainfall.

Table-2: Monthly sub divisional rainfall performance during SWM 2019

Sub-division	June			July			Aug			Sep		
	ACL (mm)	NOR (mm)	PDN (%)	ACL (mm)	NOR (mm)	PDN (%)	ACL (mm)	NOR (mm)	PDN (%)	ACL (mm)	NOR (mm)	PDN (%)
CAP	66.4	105.2	-37	170.2	157.9	8	177.4	162.1	9	227.5	161.7	41
TEL	85.7	132	-35	218.8	236.2	-7	260	227.5	14	241.1	163.9	47
RYS	54.4	70.9	-23	63.7	92.6	-31	110.7	108.5	2	231.3	139.6	66
TN	33.3	54.1	-39	59.6	76.0	-22	127.1	93.7	36	176.7	118.2	50
CK	588.3	866.7	-32	1196.6	1117.8	7	1375.8	807.2	70	636.7	306.0	108
NIK	108.5	107.1	1	131.3	123.5	6	207.8	122.0	70	163.9	144.5	13
SIK	103.4	144.1	-28	166.3	213.3	-22	360.1	178.0	102	210.5	146.3	44
KER	359.0	643.0	-44	574.3	720.0	-20	950.5	426.7	123	426.1	259.5	64
LAK	242.5	330.3	-27	489.4	294.0	66	338.5	223.2	52	156.7	165.6	-5

ACL: Actual; NOR: Normal; PDN: Percentage Departures from Normal

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



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

Fig.3: Monthly sub divisional rainfall distribution during Jun-Sep 2019

2.3 Weekly sub divisional rainfall progress

Week by week and cumulative weekly performance of SWM 2019 over the SP region are presented in Table-3a and Table 3b respectively.

Table-3a: Week by week sub divisional rainfall during June-Sep 2019over the SP region

Week by week	Week ending																
Sub division	05-Jun	12-Jun	19-Jun	26-Jun	03-Jul	10-Jul	17-Jul	24-Jul	31-Jul	07-Aug	14-Aug	21-Aug	28-Aug	04-Sep	11-Sep	18-Sep	25-Sep
COASTAL AP and YANAM	-45	-69	-80	62	-45	-49	-5	26	57	99	-46	34	-22	41	-20	51	54
TELANGANA	-14	-42	-93	11	-9	-41	-51	-31	80	151	-38	-43	-10	58	-48	78	54
RAYALASEEMA	20	-15	-95	28	-47	-89	-10	25	-63	-47	-86	144	12	-20	-78	146	166
TN, PDC and KKL	16	-27	-74	-38	-77	-58	20	-21	-20	-39	125	136	-22	-26	-43	137	88
COASTAL KARNATAKA	-92	-66	-24	-15	-15	10	-7	35	5	88	106	9	36	207	232	59	-32
NORTH INTERIOR KARNATAKA	6	-17	-78	78	18	10	7	-3	8	239	111	-29	-39	17	-5	-52	73
SOUTH INTERIOR KARNATAKA	14	-3	-58	-41	-34	34	-58	-22	-36	116	289	48	-42	17	113	-27	86
KERALA and MAHE	-69	-12	-54	-21	-86	-21	-71	131	-72	22	387	-28	98	180	130	17	11
LAKSHADWEEP	-67	47	-74	-10	-94	-81	125	245	60	-70	106	-14	196	107	-72	-69	26

Table-3b: Weekly cumulative sub divisional rainfall during Jun-Sep 2019

Cumulative weekly	Week ending																
Sub division	05-Jun	12-Jun	19-Jun	26-Jun	03-Jul	10-Jul	17-Jul	24-Jul	31-Jul	07-Aug	14-Aug	21-Aug	28-Aug	04-Sep	11-Sep	18-Sep	25-Sep
COASTAL AP and YANAM	-45	-60	-70	-31	-35	-38	-31	-21	-10	3	-3	1	-1	2	0	4	8
TELANGANA	-14	-32	-63	-39	-31	-33	-37	-36	-17	4	-1	-5	-1	-1	-3	1	4
RAYALASEEMA	20	-1	-36	-21	-25	-37	-32	-22	-28	-30	-36	-17	-14	-14	-20	-4	13
TN, PDC and KKL	7	-12	-34	-35	-42	-45	-33	-31	-29	-30	-14	5	2	-1	-5	10	17
COASTAL KARNATAKA	-90	-72	-48	-37	-31	-23	-20	-12	-10	0	10	10	11	18	24	25	23
NORTH INTERIOR KARNATAKA	37	3	-29	-1	3	4	5	3	4	31	40	34	29	28	26	20	24
SOUTH INTERIOR KARNATAKA	27	9	-20	-26	-28	-15	-23	-23	-25	-8	21	23	18	18	23	20	24
KERALA and MAHE	-70	-30	-41	-35	-48	-43	-47	-26	-32	-27	0	-1	3	9	13	13	13
LAKSHADWEEP	-55	10	-19	-17	-31	-40	-15	14	17	11	17	15	26	30	25	20	45

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

During the 17 weeks covering the SWM season of 2019, CK & NIK recorded maximum number of *normal* to *excess* rainfall weeks (13 weeks). TN recorded maximum number of *deficient* to *large deficient* weeks (11 weeks).During the weeks ending 07th& 14thAugust,six subdivisions in the region recorded *excess* to large *excess* rainfall. In the week ending 19th June all subdivisions in the region recorded *deficient* to *largely deficient* rainfall.

Considering the cumulative seasonal rainfall performance at the end of each week, it is noted that by the end of the week ending 03rd July, excepting NIK that came under *normal* category, all subdivisions in the region had received only *deficient* rainfall; however, by the end of the week ending 31st July, aside from NIK that continued to remain under *normal* category, rainfall performance over CAP, TEL, CK and LAK also came under *normal* category and by the end of week ending 21st August, all the subdivisions in the region came under *normal* to *excess* category and this continued through the subsequent weeks during the season also.

2.4 Daily sub divisional rainfall and monsoon activity

The mean daily rainfall for the entire SP region during the season is depicted in Fig.4.Table-4apresents daily spatial rainfall distribution over various subdivisions of the SP region during the SWM 2019 and Table-4b, the percentage frequency of various categories of spatial rainfall distribution over each subdivision during the season.

As seen, the daily rainfall over the SP region up to the 18th July has been generally below normal on most of the days. However, rainfall activity picked subsequently with intense rain spells during 5-10 August and 18-26 Sep 2019. However, CK & KER experienced *fairly widespread* to w*idespread* rainfall distribution on 90% & 79% of the days respectively. TN & RYS reported only *isolated* rainfall to *dry* conditions on 66% and 61% of the days respectively. During the period, 19th June to 17th Sep [91 days], CK experienced *WS* rainfall distribution on all days except the 18th July, when it experienced *FWS* rainfall distribution. During the period 05-10 August, five subdivisions - CK, NIK, SIK, KER and LAK experienced *FWS-WS* rainfall distribution on all the days.

Table-5 presents the monthly and seasonal frequency of *active* and *vigorous* monsoon days over the various subdivisions of the SP region during the SWM season, 2019. CK and KER experienced 36 days of *active* to *vigorous* monsoon activity during the season of which 17 and 15 days respectively were during the month of August and 11 and 14 days respectively were during the month of September. SIK and NIK experienced 25-28 days of *active* to *vigorous* monsoon activity, TEL and CAP, 22-23 days, RYS-16 days and TN-10 days of *active* to *vigorous* monsoon activity.

Table-4a: Daily sub divisional rainfall distribution over the SP region during SWM 2019

Date as on 24 hr ending 0830 IST	CAP	TEL	RYS	TN	CK	NIK	SIK	KER	LAK
01-Jun	ISOL	ISOL	ISOL	ISOL	SCT	SCT	FWS	FWS	FWS
02-Jun	ISOL	ISOL	ISOL	ISOL	DRY	ISOL	ISOL	ISOL	SCT
03-Jun	ISOL	ISOL	FWS	ISOL	FWS	FWS	WS	FWS	DRY
04-Jun	SCT	SCT	DRY	ISOL	ISOL	FWS	DRY	SCT	FWS
05-Jun	DRY	DRY	ISOL	SCT	DRY	ISOL	ISOL	ISOL	SCT
06-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	WS	WS	WS
07-Jun	SCT	ISOL	ISOL	ISOL	SCT	FWS	FWS	FWS	FWS
08-Jun	ISOL	FWS	ISOL	ISOL	SCT	FWS	SCT	SCT	WS
09-Jun	ISOL	ISOL	DRY	ISOL	SCT	ISOL	ISOL	FWS	WS
10-Jun	ISOL	ISOL	SCT	ISOL	ISOL	SCT	SCT	WS	WS
11-Jun	ISOL	ISOL	ISOL	ISOL	WS	ISOL	SCT	WS	WS
12-Jun	ISOL	ISOL	ISOL	ISOL	WS	ISOL	SCT	WS	WS
13-Jun	ISOL	ISOL	DRY	ISOL	WS	SCT	SCT	WS	WS
14-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	WS	FWS
15-Jun	ISOL	DRY	ISOL	ISOL	WS	ISOL	FWS	WS	FWS
16-Jun	ISOL	DRY	ISOL	ISOL	WS	ISOL	SCT	WS	FWS
17-Jun	SCT	ISOL	ISOL	ISOL	FWS	DRY	ISOL	SCT	SCT
18-Jun	SCT	SCT	ISOL	ISOL	FWS	DRY	ISOL	SCT	FWS
19-Jun	ISOL	ISOL	ISOL	ISOL	WS	ISOL	SCT	WS	WS
20-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	WS	FWS
21-Jun	FWS	FWS	ISOL	ISOL	WS	ISOL	ISOL	WS	WS
22-Jun	SCT	SCT	ISOL	ISOL	WS	FWS	SCT	WS	WS
23-Jun	FWS	SCT	SCT	ISOL	WS	SCT	FWS	WS	WS
24-Jun	SCT	SCT	SCT	ISOL	WS	WS	FWS	WS	FWS
25-Jun	SCT	SCT	SCT	ISOL	WS	FWS	SCT	WS	FWS
26-Jun	ISOL	ISOL	ISOL	ISOL	WS	ISOL	SCT	FWS	DRY
27-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	ISOL	DRY
28-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	FWS	ISOL	DRY
29-Jun	ISOL	FWS	ISOL	ISOL	WS	FWS	SCT	SCT	DRY
30-Jun	ISOL	FWS	ISOL	ISOL	WS	WS	SCT	SCT	DRY
01-Jul	FWS	FWS	SCT	ISOL	WS	FWS	SCT	SCT	SCT
02-Jul	FWS	FWS	ISOL	ISOL	WS	FWS	SCT	FWS	FWS
03-Jul	SCT	FWS	ISOL	ISOL	WS	FWS	FWS	WS	FWS
04-Jul	ISOL	SCT	ISOL	ISOL	WS	WS	FWS	WS	FWS
05-Jul	FWS	SCT	ISOL	ISOL	WS	WS	FWS	WS	FWS
06-Jul	FWS	FWS	ISOL	ISOL	WS	FWS	WS	WS	SCT
07-Jul	SCT	ISOL	ISOL	ISOL	WS	SCT	FWS	WS	SCT
08-Jul	SCT	FWS	ISOL	ISOL	WS	FWS	FWS	WS	SCT
09-Jul	SCT	FWS	DRY	ISOL	WS	FWS	SCT	WS	SCT
10-Jul	ISOL	SCT	ISOL	SCT	WS	FWS	WS	WS	WS
11-Jul	SCT	SCT	ISOL	ISOL	WS	WS	FWS	WS	WS
12-Jul	ISOL	FWS	ISOL	ISOL	WS	FWS	FWS	SCT	FWS
13-Jul	ISOL	ISOL	ISOL	ISOL	WS	FWS	SCT	ISOL	SCT
14-Jul	WS	SCT	SCT	ISOL	WS	SCT	SCT	SCT	WS
15-Jul	SCT	SCT	ISOL	SCT	WS	FWS	SCT	FWS	WS
16-Jul	FWS	ISOL	ISOL	SCT	WS	SCT	SCT	WS	WS
17-Jul	ISOL	ISOL	SCT	ISOL	WS	SCT	SCT	FWS	WS
18-Jul	SCT	ISOL	ISOL	ISOL	FWS	SCT	SCT	WS	WS
19-Jul	WS	SCT	SCT	SCT	WS	FWS	FWS	WS	WS
20-Jul	FWS	WS	SCT	SCT	WS	WS	FWS	WS	WS
21-Jul	FWS	SCT	ISOL	ISOL	WS	FWS	SCT	FWS	FWS
22-Jul	FWS	SCT	ISOL	ISOL	WS	FWS	SCT	FWS	FWS
23-Jul	SCT	ISOL	SCT	SCT	WS	FWS	WS	WS	FWS
24-Jul	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	WS	WS
25-Jul	SCT	ISOL	SCT	ISOL	WS	SCT	FWS	WS	WS
26-Jul	WS	WS	ISOL	SCT	WS	FWS	WS	WS	WS
27-Jul	WS	WS	SCT	ISOL	WS	WS	FWS	SCT	WS
28-Jul	FWS	FWS	ISOL	ISOL	WS	SCT	FWS	SCT	DRY
29-Jul	FWS	WS	ISOL	ISOL	WS	FWS	FWS	FWS	SCT
30-Jul	SCT	WS	ISOL	ISOL	WS	WS	SCT	FWS	SCT
31-Jul	SCT	SCT	ISOL	ISOL	WS	WS	SCT	SCT	FWS

Date as on 24 hr ending 0830 IST	CAP	TEL	RYS	TN	CK	NIK	SIK	KER	LAK
01-Aug	SCT	FWS	ISOL	ISOL	WS	FWS	ISOL	SCT	DRY
02-Aug	WS	WS	FWS	ISOL	WS	WS	ISOL	SCT	DRY
03-Aug	WS	WS	SCT	ISOL	WS	WS	SCT	FWS	DRY
04-Aug	SCT	WS	SCT	ISOL	WS	WS	SCT	FWS	DRY
05-Aug	ISOL	SCT	ISOL	ISOL	WS	WS	FWS	WS	WS
06-Aug	FWS	WS	SCT	SCT	WS	WS	WS	WS	FWS
07-Aug	FWS	WS	ISOL	SCT	WS	FWS	WS	WS	WS
08-Aug	FWS	WS	SCT	SCT	WS	WS	WS	WS	WS
09-Aug	FWS	FWS	ISOL	SCT	WS	WS	WS	WS	WS
10-Aug	ISOL	ISOL	ISOL	ISOL	WS	FWS	WS	WS	WS
11-Aug	ISOL	ISOL	ISOL	ISOL	WS	SCT	FWS	WS	DRY
12-Aug	ISOL	SCT	ISOL	ISOL	WS	SCT	FWS	WS	FWS
13-Aug	SCT	SCT	ISOL	ISOL	WS	SCT	WS	WS	FWS
14-Aug	SCT	SCT	ISOL	SCT	WS	SCT	FWS	WS	WS
15-Aug	SCT	FWS	ISOL	ISOL	WS	FWS	WS	WS	WS
16-Aug	SCT	ISOL	SCT	ISOL	WS	FWS	FWS	WS	FWS
17-Aug	SCT	ISOL	FWS	FWS	WS	ISOL	WS	WS	WS
18-Aug	FWS	ISOL	SCT	SCT	WS	SCT	FWS	SCT	WS
19-Aug	FWS	SCT	FWS	SCT	WS	FWS	WS	FWS	WS
20-Aug	SCT	SCT	WS	SCT	WS	ISOL	FWS	SCT	FWS
21-Aug	SCT	SCT	FWS	FWS	WS	ISOL	FWS	WS	FWS
22-Aug	FWS	FWS	FWS	SCT	WS	SCT	SCT	WS	WS
23-Aug	SCT	WS	FWS	SCT	WS	FWS	FWS	WS	WS
24-Aug	SCT	SCT	ISOL	SCT	WS	WS	FWS	WS	WS
25-Aug	FWS	SCT	SCT	ISOL	WS	FWS	FWS	WS	WS
26-Aug	ISOL	SCT	ISOL	SCT	WS	ISOL	SCT	WS	WS
27-Aug	ISOL	ISOL	ISOL	ISOL	WS	ISOL	FWS	WS	WS
28-Aug	ISOL	ISOL	ISOL	ISOL	WS	ISOL	ISOL	WS	WS
29-Aug	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	WS	WS
30-Aug	ISOL	SCT	ISOL	ISOL	WS	ISOL	SCT	WS	SCT
31-Aug	FWS	WS	ISOL	ISOL	WS	SCT	SCT	WS	WS
01-Sep	FWS	WS	FWS	ISOL	WS	WS	SCT	WS	WS
02-Sep	WS	WS	SCT	ISOL	WS	FWS	FWS	WS	FWS
03-Sep	WS	WS	SCT	SCT	WS	FWS	FWS	WS	WS
04-Sep	FWS	FWS	FWS	SCT	WS	FWS	WS	WS	FWS
05-Sep	FWS	FWS	SCT	SCT	WS	FWS	WS	WS	FWS
06-Sep	FWS	SCT	SCT	ISOL	WS	FWS	WS	WS	SCT
07-Sep	FWS	FWS	ISOL	ISOL	WS	FWS	FWS	WS	FWS
08-Sep	SCT	ISOL	SCT	ISOL	WS	WS	FWS	WS	DRY
09-Sep	ISOL	SCT	ISOL	ISOL	WS	SCT	SCT	FWS	DRY
10-Sep	SCT	SCT	DRY	ISOL	WS	SCT	SCT	WS	WS
11-Sep	ISOL	SCT	ISOL	SCT	WS	SCT	SCT	WS	FWS
12-Sep	SCT	FWS	ISOL	FWS	WS	ISOL	SCT	WS	SCT
13-Sep	SCT	FWS	ISOL	SCT	WS	ISOL	FWS	FWS	WS
14-Sep	SCT	SCT	ISOL	FWS	WS	ISOL	ISOL	SCT	SCT
15-Sep	SCT	FWS	SCT	SCT	WS	SCT	SCT	FWS	DRY
16-Sep	ISOL	SCT	FWS	FWS	WS	ISOL	SCT	WS	WS
17-Sep	SCT	SCT	WS	FWS	WS	FWS	WS	FWS	FWS
18-Sep	WS	WS	WS	SCT	FWS	FWS	FWS	WS	FWS
19-Sep	WS	FWS	WS	SCT	WS	WS	FWS	WS	FWS
20-Sep	WS	WS	WS	SCT	WS	WS	SCT	FWS	SCT
21-Sep	SCT	FWS	ISOL	ISOL	FWS	ISOL	ISOL	SCT	FWS
22-Sep	SCT	SCT	FWS	SCT	FWS	ISOL	SCT	SCT	FWS
23-Sep	SCT	SCT	SCT	FWS	ISOL	ISOL	FWS	FWS	SCT
24-Sep	FWS	FWS	FWS	FWS	SCT	WS	WS	WS	FWS
25-Sep	WS	WS	FWS	SCT	FWS	WS	FWS	WS	WS
26-Sep	WS	WS	FWS	WS	WS	WS	WS	WS	WS
27-Sep	FWS	WS	SCT	ISOL	WS	WS	SCT	FWS	WS
28-Sep	SCT	SCT	SCT	ISOL	ISOL	ISOL	SCT	ISOL	DRY
29-Sep	ISOL	ISOL	ISOL	ISOL	ISOL	ISOL	SCT	SCT	DRY
30-Sep	SCT	SCT	ISOL	FWS	ISOL	ISOL	SCT	WS	SCT

Table-4b: Percentage frequency of various categories of daily spatial rainfall distribution over the sub divisions of the SP region during SWM season, 2019

Category	Frequency (%)								
	CAP	TEL	RYS	TN	CK	NIK	SIK	KER	LAK
WS	11	17	4	1	83	20	17	61	42
FWS	23	20	11	7	7	32	33	18	30
SCT	34	31	23	25	4	24	40	16	15
ISOL	32	29	57	66	5	22	9	5	0
DRY	1	2	4	0	2	2	1	0	14

***WS**: Widespread; **FWS**: Fairly Widespread; **SCT**: Scattered; **ISOL**: Isolated; **DRY**: No rain*
(Note:Kindly refer Appendix(i) for explanations on categorization of spatial rainfall distribution)

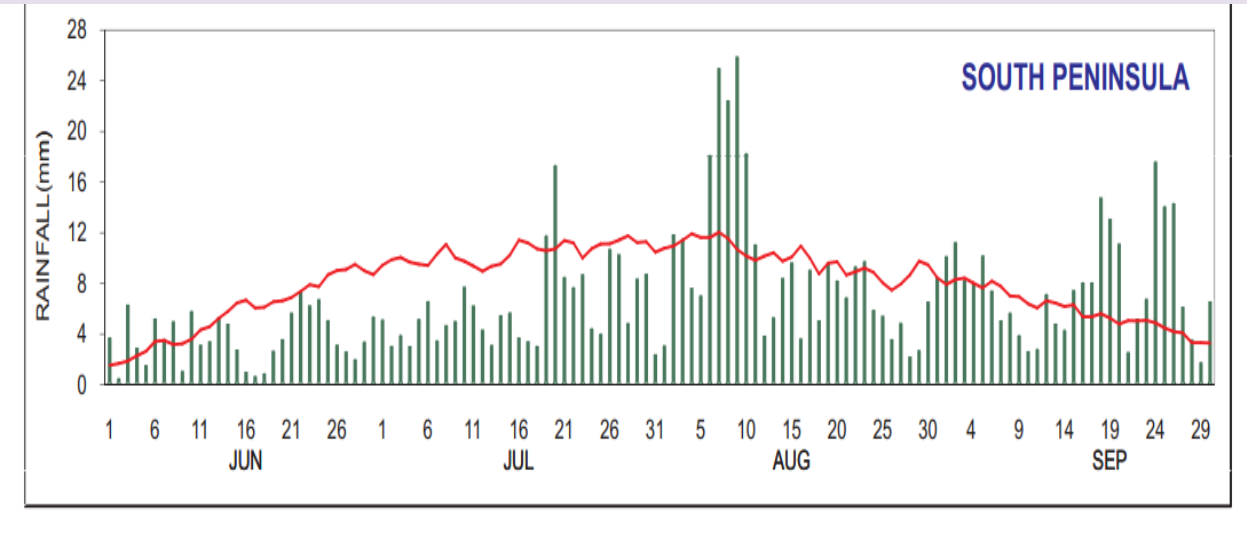


Fig.4: Mean daily rainfall over southern peninsular region during SWM season, 2019

Table-5: Sub division-wise frequency of Vigorous and Active monsoon conditions over the SP region during SWM season, 2019

Subdivision	JUN		JUL		AUG		SEP		Jun-Sep	
	ACT	VIG	ACT	VIG	ACT	VIG	ACT	VIG	ACT	VIG
COASTAL AP and YANAM	1	0	7	0	4	2	8	1	**20**	**3**
TELANGANA	1	0	6	0	4	3	6	2	**17**	**5**
RAYALASEEMA	0	0	0	0	5	2	6	3	**11**	**5**
TAMIL NADU, PDC and KKL	0	0	0	0	1	1	7	1	**8**	**2**
COASTAL KARNATAKA	2	0	6	0	16	1	7	4	**31**	**5**
NORTH INTERIOR KARNATAKA	3	1	6	0	6	4	7	1	**22**	**6**
SOUTH INTERIOR KARNATAKA	0	0	3	0	7	5	9	1	**19**	**6**
KERALA and MAHE	1	0	6	0	8	7	14	0	**29**	**7**
LAKSHADWEEP	0	0	0	0	0	0	0	0	**0**	**0**

ACT: Active monsoon conditions (FWD to WD rainfall over the subdivision with rainfall amount 1½ to 4 times the normal and at least 2 stations reporting 5 cm or more along the west coast or 3 cm or more elsewhere)

VIG: Vigorous monsoon conditions (FWD to WD rainfall over the subdivision with rainfall amount more than 4 times the normal and at least 2 stations reporting 8 cm or more along the west coast or 5 cm or more elsewhere).

2.5 District-wise seasonal rainfall distribution

Table -6 presents the district rainfall distribution as percentage departures from normal over the nine meteorological subdivisions of the SP region during the period Jun-Sep 2019 and Fig.5, the district-wise seasonal rainfall over the various states and UTs over the SP region.

Table-6: District rainfall performance over various sub divisions of the SP region during June-September, 2019

Met. Sub division	Total No. of districts	No. of districts under various categories of monsoon performance				
		Large Excess	*Excess*	*Normal*	*Deficient*	*Large Deficient*
COASTAL AP and YANAM	10	0	2	8	0	0
RAYALASEEMA	4	0	0	4	0	0
TELANGANA	31	0	6	22	3	0
TAMIL NADU, PDC and KKL	34	3	14	16	1	0
COASTAL KARNATAKA	3	0	2	1	0	0
NORTH INTERIOR KARNATAKA	11	1	4	6	0	0
SOUTH INTERIOR KARNATAKA	16	1	6	8	1	0
KERALA and MAHE	15	0	3	12	0	0
LAKSHADWEEP	1	0	1	0	0	0

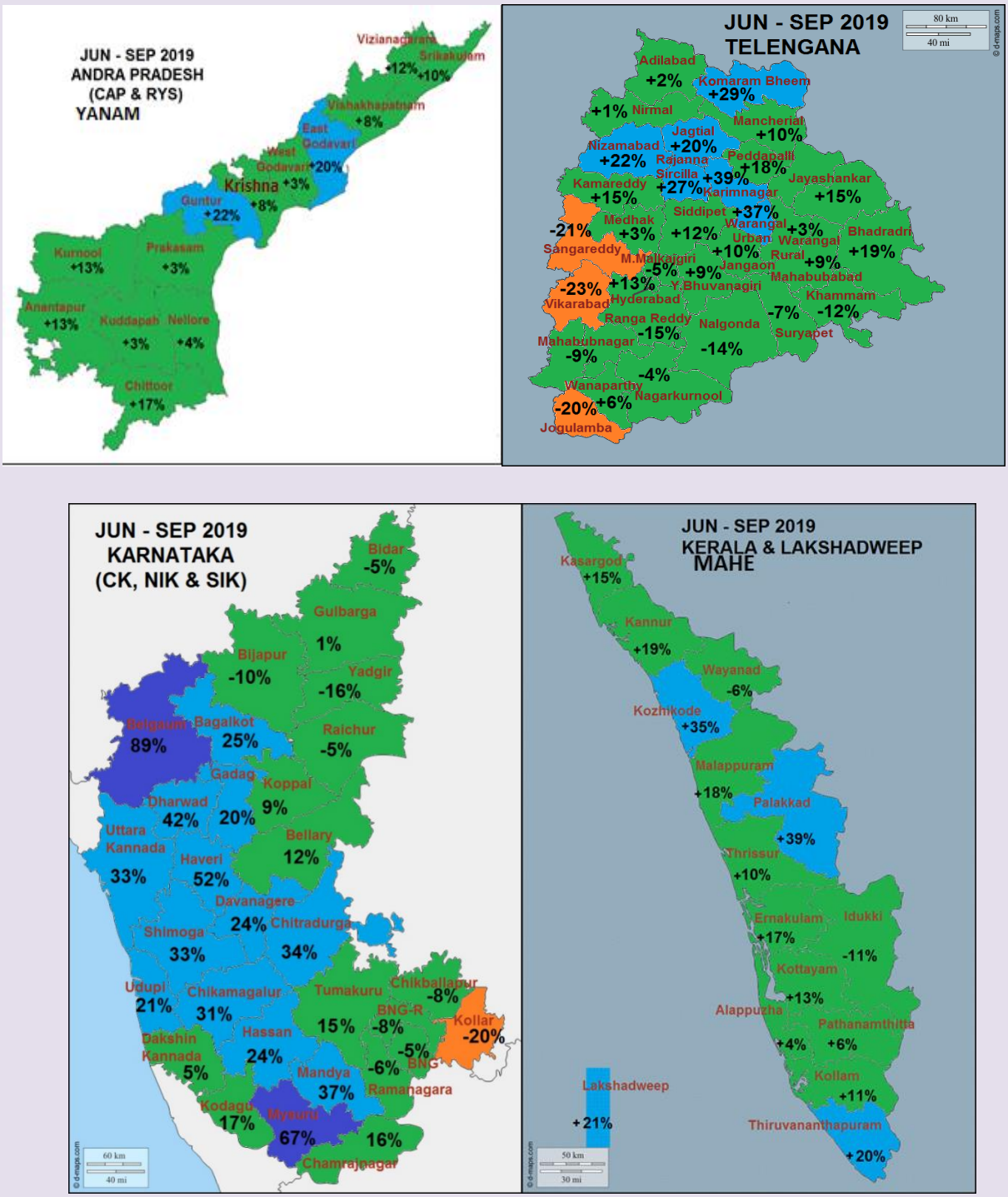


Fig.5: District-wise seasonal rainfall (percentage departure from normal) over various states and union territories in the SP region

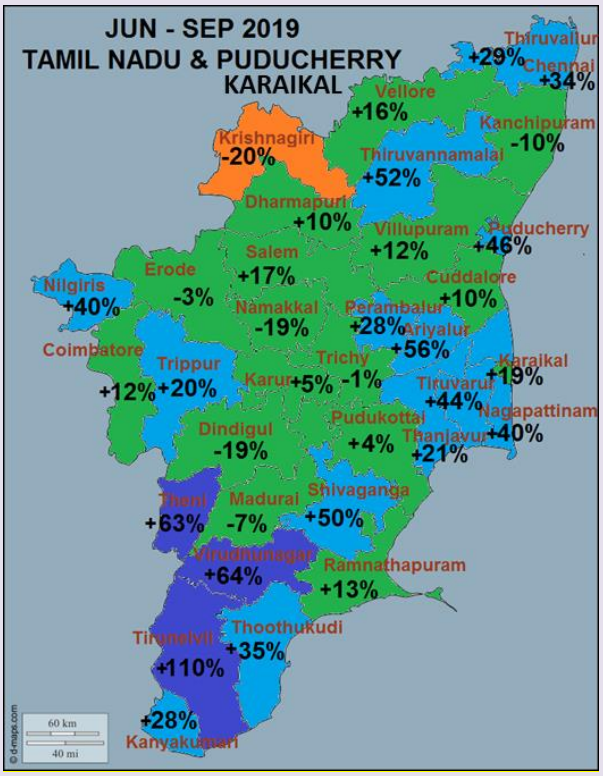


Fig.5 (contd.)

Of the 125 districts in the SP region [Andhra Pradesh: 14 (CAP-10& RYS-4), Telangana: 31, TamilNadu and Puducherry: 34 (32 and 2 respectively), Karnataka: 30 (CK-3, NIK-11 & SIK-16), Kerala, Mahe and Lakshadweep: 16 (15 and 1 respectively)], 115 districts received *normal to excess* rainfall during the season.5 districts [1 (Belagavi) in NIK, 1 (Mysuru) in SIK and 3 (Tirunelveli, Theni and Virudunagar) in TN] received *large excess* rainfall during the season. The remaining 5 districts [1 (Krishnagiri) in TN, 1 (Kolar) in SIK, and 3 (Sangareddy, Vikarabad, Jogulamba Gadwal) in TEL] came under the *deficient* category. Tirunelveli district in TN recorded large excess rainfall of +110% (269.0 mm out of the normal rainfall of 128.4 mm) followed by Belagavi in NIK, +89% (1083.1 mm out of the normal rainfall of 572.1 mm). However, the deficiency in the five deficient districts in the region were only marginal (-20% to -23%).

2.6 Heavy rainfall activity and extreme rainfall events

Table-7a presents the number of days of *heavy* rainfall occurrences (≥ 7 cm/day) over the various subdivisions of the SP region during SWM 2019 and the month-wise frequencies are presented in Table 7b.In the seasonal scale, CK recorded 76 days of heavy rainfall events which included 40days of isolated *very heavy* rainfall occurrenceswith9 days of *extremely heavy* rainfall events. KER and TN reported 61and 59 days respectively of *heavy* rainfall occurrences with 21and 19 days respectively of *isolated very heavy* rainfall and 5and 6 days respectively of *isolated extremely heavy* rainfall during the season. SIK and CAP recorded 54 days of *heavy* rainfall events; TEL and NIK, 47 and 35 days respectively of heavy rainfall events; RYS and LAK reported only 27 and 8 days respectively of *heavy* rainfall occurrence. List of *very heavy* to *extremely heavy* rainfall events is presented in Table 7c.

In the monthly scale, there were 12, 27, 24 and 13 days of *heavy* rainfall events over CK during June, July, August and September respectively. The corresponding monthly figures for KER were 14, 14, 18 and 15 days; 7, 14, 17 and 16 days for SIK; 6, 16, 14 and 18 days for CAP; 8, 11, 13 and 15 days for TEL; 9, 14, 17 and 19 days for TN; 6, 2, 7 and 12 days for RYS and 1, 5, 2 and Nil days for LAK. Considering the *heavy* rainfall activity on daily basis, it may be mentioned that there were two major intense spells of *very heavy -extremely heavy* rainfall events – (i) 19th-23rd July over CK and KER and (ii) 6th-11th August over CK, SIK, KER and TN. NIK also recorded isolated *very heavy -extremely heavy* rainfall activity during 6th-9th August 2019. INSAT-3D infra red imageries depicting the cloudiness association with the intense rainfall activity during 07th-10th August 2019 are presented in Fig.6a. IMD gridded rainfall map depicting the extreme rainfall events on 19th July and 8th-10th Aug 2019 are presented in Fig. 6b. Gauge observed rainfall plots for Kerala, Karnataka and Tamil Nadu for 8th – 10th Aug 2019 depicting the intense heavy rainfall distribution are presented in Fig. 6c. It is noted that this extreme rainfall activity occurred over the western ghat areas of Kerala, Karnataka and Tamil Nadu under the influence of Orography along with the favourable synoptic situation.

Table-7a: Subdivision-wise frequency of heavy rainfall days over the SP region during 1st June-30th Sep 2019

Subdivision	No. of days of Heavy rainfall (Rainfall ≥ 7 cm/day)		
	Extremely Heavy (≥21 cm/day)	*Very Heavy* (≥12 cm/day)	*Heavy* (≥7 cm/day)
COASTAL AP and YANAM	2	11	54
TELANGANA	2	13	47
RAYALASEEMA	0	8	27
TAMIL NADU, PDC and KKL	6	19	59
COASTAL KARNATAKA	9	40	76
NORTH INTERIOR KARNATAKA	1	12	35
SOUTH INTERIOR KARNATAKA	8	23	54
KERALA and MAHE	5	21	61
LAKSHADWEEP	0	2	8

Note: Kindly refer Appendix-(ii) for explanations on various terminologies used for description of rainfall intensity.

Table-7b: Month-wise frequency of heavy rainfall days during June-Sep 2018

Sub-division	No. of days of Heavy rainfall (Rainfall ≥ 7 cm/day)											
	June			July			Aug			Sep		
	ExH	*VH*	*H*	*ExH*	*VH*	*H*	*ExH*	*VH*	*H*	*ExH*	*VH*	*H*
COASTAL AP and YANAM	0	0	6	0	1	16	1	3	14	1	7	18
TELANGANA	0	0	8	0	4	11	1	6	13	1	3	15
RAYALASEEMA	0	0	6	0	0	2	0	1	7	0	7	12
TAMIL NADU , PDC and KKL	0	0	9	0	0	14	5	11	17	1	8	19
COASTAL KARNATAKA	0	7	12	2	12	27	6	16	24	1	5	13
NORTH INTERIOR KARNATAKA	0	0	5	0	3	11	1	8	12	0	1	7
SOUTH INTERIOR KARNATAKA	0	0	7	0	6	14	7	10	17	1	7	16
KERALA and MAHE	0	4	14	1	5	14	4	10	18	0	2	15
LAKSHADWEEP	0	0	1	0	1	5	0	1	2	0	0	0

***ExH: Extremely Heavy* (≥21 cm/day); *VH*: *Very Heavy* (≥12 cm/day); *H*: *Heavy* (≥7 cm/day)**

Table-7c: District-wise list of stations & dates of *very heavy -extremely heavy* rainfall along with the respective rainfall amounts during the SWM 2019	
Coastal Andhra Pradesh	
East Godavari	Jun: 27th:Amalapuram-13 Aug :02nd: Chintur-17, Vararamachandrapur-13, Kunavaram-13; 07th: Chintur-21, Vararamachandrapur-13, Kunavaram-13
West Godavari	Aug :07th: Koida-14, Velairpad-13
Krishna	Jul :14th: Gudivada-15 Sep :02nd: Nuzvid-14; 26th:Nuzvid-13; 28th: Nuzvid-13
Vishakhapatnam	Aug :07th:Paderu-12
Prakasam	Aug :20th:Mundlamuru-12
Guntur	Sep :15th:Lam-12; 18th:Guntur-21,Tenali-17
Nellore	Sep :19th:Seetharamapuram-12
Srikakulam	Sep :26th:Sompeta-15, Ichhapuram-15
Telangana	
Kamareddy	Jul :20th:Tadwai-14, Kamareddy-14, Yellareddy-13 Sep :01st:Bhiknur-14, Tadwai-12 Sep :02nd:Gandhari-14
Nizamabad	Jul :20th:Bodhan-13, Dhar Palle-13, Ranjal-12, Navipet-12 Sep :18th:Mortad-12
KumaramBheem	Jul :20th:Jainoor-12; 30th:Bejjur-21, Sirpur-18, Kagaznagar-13, Dahegaon-12
Medak	Jul :20th:Papannapet-13
Bhupalpally	Jul :27th:Venkatapur-12 Aug :02nd: Venkatapur-22, Venkatapuram-18, Govindaraopet-14 Aug :07th: Venkatapuram-17,Eturnagaram-14, Perur-12 Aug :08th: Venkatapur-13, Govindaraopet-13 Sep :01st:Mugullapalle-14,
Adilabad	Jul :30th:Adilabad-12 Aug :03rd:Bazarhathnoor-13 Aug :04th:Utnur-17
Kothagudem	Aug :02nd:Mulakalapalle-14, Bhadrachalam-12, Aswapuram-12
Warangal (Rural)	Aug :02nd:Parkal-12 Sep :01st:Chennaraopet-14,
Nirmal	Aug :07th:Modhole-12

	Sep :18th:Shriramsag. Pocha-12
Nalgonda	Sep :18th:Nalgonda-22, Nidamanur-14, Chandur-13
Mancherial	Sep :18th:Bheemini-15
Y.Bhuvanagiri	Sep :18th:Atmakur M-12
RajannaSircilla	Sep :18th:Vemulawada-12
Suryapet	Sep :18th:Neredcherla-12
Rayalaseema	
Kurnool	Aug :17th:Rudravaram-16 Sep :16th:Rudravaram-18, Nandyal-13, Allagadda-12; 17th:Allagadda-18,Rudravaram-13, Dornipadu-12; 19th:Peapalle-12; 20th:Allagadda-14,Rudravaram-13,
Chittoor	Sep :12th:Nagari-13; 15th:chittoor-14; 19th:Chittoor-15, Nagari-12,Puttur-12
Cuddapah	Sep :16th:Raju Palem-15, Proddutur-12, Duvvur-12, Kondapuram-12; 20th:Sambepalle-12
Anantapur	Sep :17th:Bathalapalle-12; 20th:Nambulipulikunta-12; 28th:Rayadurg-17,Gummagatta-12
Tamil Nadu	
Nilgiris	Aug :05th:Avalanche-21; 06th:Avalanche-18; 07th:Avalanche-41, Upper Bhavani-22, Naduvattam-12; 08th:Avalanche-82,Upper Bhavani-30, G Bazar-24, Devala-21, Naduvattam-18, Emarald-18, Glenmorgan-15; 09th:Upper Bhavani-45, Emarald-36, Devala-26, G Bazar-25, Naduvattam-22, Glenmorgan-21,K Bridge-19, Uthagamandalam-18; 10th:Avalanche-35,Upper Bhavani-19, Devala-16, Naduvattam-14, G Bazar-13 Sep :05th:G Bazar-15
Coimbatore	Aug :06th:Valparai Pto-14; 08th:Chinnakalar-23, Valparai Pto-20,ValparaiTaluk Office-14; 09th:Chinnakalar-37, Valparai PTO-35,Solaiyar-28, ValparaiTaluk Office-26, Alaiyaar-17, Pollachi-16,Coimbatore South-12; 10th:Chinnakalar-13
Theni	Aug :08th:Periyar-18; 09th:Thekkadi-23, Periyar-20
Vellore	Aug :17th:Vellore-17; 18th:Alangayam-15; 19th:Melalathur-12, Ambur-12 Sep :19th:Arakonam-17
Cuddalore	Aug :17th:Kuddalore-13
Ariyalur	Aug :17th:Ariyalur-12 Sep :12th:Jayamkondam-14; 14th:Ariyalur-15
Sivaganga	Aug :19th:Tirupuvanam-17
Trichi	Aug :20th:Trichiraapalli Ap-13
Nagapattinam	Sep :12th:Mayiladuthurai-13
Thanjavur	Sep :14th:Thiruvidaimarithur-15, Kumbakonam-12
Tiruvannamalai	Sep :15th:Vandavasi-12
Tiruvallur	Sep :19th:Tiruvallur-22, Pondi-21,Thamaraipakkam-15, Cholavaram-13, Thiruvalangadu-13, Tiruttani-12

Dindigul	Sep :24th:Kamatchipuram-16, Vedasandur-13
Villupuram	Sep :24th:Kallakurichi-14, Kallakurichi Arg-13
Virudhunagar	Sep :30th:Watrap-15,Srivilliputhur-13
Coastal Karnataka	
Uttar Kannada	Jun :12th:Kumta-14; 13th: Gersoppa-12; 20th: Shirali-16 , Manki-13, Karwar-13; 22nd: Ankola-20, Gokarna-14, Manki-13; 23rd:Manki-12 26th:Gokarna-13; Jul :10th: Castle Rock-17, Gersoppa-14 , Kumta-12;11th: Yellapura-18, Bhatkal-15, Manki-15;15th: Gokarna-14, Manki -13, Karwar Obsy-13 HonavarObsy–13;22nd:Bhatkal-14; 23rd:Bhatkal-23, Kumta-20, Gersoppa-15, Ankola-14, Karwar-14, Honavar-13, Manki-12; 27th: Kadra – 15, Gokarna–12; 29th: Manki – 19, Castle Rock – 14, Gerosappa–13 Aug :05th:Siddapur-13; 06th: Siddapur-28, Manki-27, Yellapura-24, Kadra-19; Honnavar-15, Banavasi-15, Gokarna-14, Kumta-14, Haliyal-13; 07th:Yellapur-22, Haliyal-15, Banavasi-13, Kadra-13; 08th:Yellapur-21, Haliyal-17, Manki-16, Siddapur-16; 09th:Yellapur-30, Mungod-17, Kiravatti–15, Kadra-13; 10th:Siddapur-21; 11th: Bhatkal – 13, ShiraliPto–13; 14th:Gokarna-14; 15th:KarwarObsy – 17,Ankola – 14 , ShiraliPto–13; 16th:Manki -14 ; 25th: Manki – 14; 30th:Manki-13; 31st:Manki-24, Bhatkal-16, Gersoppa-13 Sep :01st:Honavar Obsy-12; 02nd:Karwar Obsy-13, Manki-12, Gokarna-12: 05th:Gersoppa-13
Udupi	Jun :13th:Udupi-17, Kota-13, Kollur-12; 14th:Kollur-13; 22nd:Kollur-20; Jul :10th: Karkala-15,Kota-13;11th: Kundapur-13, Kollur-12; 23rd:Kollur-21, Kota-17, Udupi-17, Kundapur-16, Siddapura-13; 25th:Karkala-14; 26th:Kollur-25 Aug :05th:Kollur-13; 06th: Kollur-27,Siddapura-15, Panambur-12, Kota-12; 07th:Kollur-22, Karkala-12 ; 10th: Karkala-13 ; 11th: Kollur - 15; 25th: HonavarObsy–13 Sep :03rd:Kollur-21; 08th:Siddapura-14
Dakshina Kannada	Jun :13th: Mulki-12, Mani-12; Jul :20th:Panambur Obsy-13; 22nd:Panambur-13;23rd:Mani-14, Mangaluru AP Obsy-13, Mudubidre-12 Aug :06th: Mani-20, Subrahmanya-20, Puttur-15, Uppinangadi-15, Dharmasthala-14,Mangaluru AP-13, Belthangadi-13 07th: Subraamanya-19, Sulya-15; 08th:Subramanya-13; 09th: Subramanya-14, Belthangadi-12; 10th: Subramanya-31, Dharmasthala-23, Belthangadi-22, Uppinangadi-17, Mangalore Ap Obsy-17, Mudubidre-17,Mani-15, Sulya-14, Panambur Obsy-13; 11th: Subramanya-17, Mangaluru – 14 , PanamburObsy – 13 , Bantwal–12; 15th:Subramanya–12 ; 22nd: Mangaluru–12; 27th: Mangaluru–14 Sep :05th:Sulya-13, Mani-13; 08th:Subramanya-13

South Interior Karnataka	
Chikkamagaluru	Jul :05th: Kottigehara-15; 06th:Mudigere-15; 07th: Kottigehara-12; 10th: Shirali-13, Kottigehara-13; 23rd: Shirali PTO-18 Aug :04th:Kottigehara-17; 05th:Kalasa-12; 06th: Kottigehara-21, Koppa-15,Sringeri-14, Kalasa-14; 07th:Sringeri Hms-18, Koppa-16, Jayapura-15, Kalasa-13, N R Pura-13; 08th:Kottigehara-31, Kalasa-26, Sringeri Hms-26, Mudigere-18, Jayapura-18, Koppa-13, Balehonnur-12; 09th:Kalasa-27,Mudigere-22,Sringeri Hms-21, Koppa-20, Kammardi-15, Jayapura-14, Balehonnur-12; 10th:Kalasa – 32, Mudigere-29, Kammardi-21, Jayapura-21, Sringeri Hms-17, Lakkavalli-13, N R Pura-12; 11th: Kammardi -23, Koppa-16 ; 15th:Kammardi -13 Sep :07th:Kottigehara-13; 08th:Kottigehara-14
Shivamogga	Jul :06th:Hosanagara-16, Linganamakki-14; 07th:Hosanagar-16; 09th:Hosanagar-15, Linganamakki-14; 20th:Agumbe Emo-12; 23rd:Agumbe-12 Aug :03rd:Hosanagar-13; 04th:Hosanagar-20, 05th:Linganamakki HMS-14,Hosanagar-14; 05th:Agumbe EMO-12; 06th: Hosanagar-28, Humchadakatte-22, Linganamakki-21, Sagar-16,Talaguppa-16, Thirathahalli-15, Sorab-15,Thyagarthi-13, Arasalu-13; 07th:Hosanagar-25,Hunchadakatte-21, Thalaguppa-15; 08th:Hosanagar-22,Hunchadakatte-15, Anavatti-13, Thalaguppa-12; 09th:Hunchadakatte-29,Bhadravati-18, Hosanagar-17, Arasalu-12; 10th:Hunchadakatte-39, Linganamakki Hms-27, Hosanagar-23, Thirthahalli-19, Sagar-16,Thalaguppa-14 ; 15th:AgumbeEmo–21 Sep :03rd:Hosanagar-13; 04th:Agumbe Emo-17; 09th:Agumbe Emo-13
Kodagu	Jul :06th:Bhagamandala-12 Aug :04th:Bhagamandala-15;06th: Shirali-18, Ponnampet-18; 07th:Bhagamandala-29, Ponnampet-21, Napoklu-20, Virajpet-15 Madikeri Pto-14, Somwarpet-12; 08th:Napoklu-23, Madikeri Pto-19, Virajpet-19, Somwarpet-16; 09th:Bhagamandala-40, Virajpet-27, Ponnampet Pwd-26, Madikeri Pto-18, Somwarpet-13 10th:Bhagamandala-26,Ponnampet Pwd-19, Virajpet-18, Madikeri Pto-13 Sep :05th:Bhagamandala-26, Ponnampet-14, Madikeri Pto-14, Napoklu-13;09th:Bhagamandala-12
Chitradurga	Aug :06th: Parasurampura-15
Hassan	Aug :08th:Sakleshpura-13; 09th:Sakleshpura-15, Hassan Pto-13; 10th:Sakleshpura-19, Alur-16
Mysuru	Aug :08th:H D Kote-12; 09th:Surgur-23, H D Kote-13
Tumakuru	Sep :24th:Madhugiri-12
North Interior Karnataka	
Belagavi	Jul :08th:Londa-13; 09th:Londa-14; 30th: Khanapur–12 Aug :03rd:Londa-14; 04th:Londa-14, 05th:Londa-12; 06th: Londa-19, Khanapur-17, Kittur-13, Nippani-12; 07th:Londa-18;

	07th:Khanapur-17,Belagavi Pto-17, Kittur-14, BelagavyAp Obsy-13; 08th:Londa-27, Belagavi Pto-19, Belagavi Apo Obsy-15; 09th:Londa-19; 10th:BelagaviPto–12; 14th:Londa–12 Sep: 08th:Londa-12
Dharwad	Aug :08th:Dharwad Pto-14, Hubballi-13
Koppal	Sep :24th:Yelburga-14
Kerala	
Ernakulam	Jun :14th:Piravom-14 Jul :19th:CIAL Kochi-12, Perumpavur-12;20th:Kochi CIAL –12 Aug :06th: Kochi CIAL –12;09th:Kochi CIAL-21, Perampavur-19 , Kochi I.a.f. – 13;11th:Kochi CIAL-15
Kozhikode	Jun :19th:Vadakara-16; 20th:Vadakara-12 Jul :19th:Kozhikode-15; 20th:Vadakara-19, Quilandi - 13; 21st: Vadakara – 17 22nd: Vadakara – 20 ,Quilandy - 12; 23rd:Vadakara – 17 Aug :07th:Vadakara – 17; 09th:Vadakara-30 , Kozhikode – 14 , Quilandi – 13 , 10th:Vadakara – 30 , Quilandi–19 , Kozhikode – 13; 11th:Vadakara-21; 15th:Vadakara-16
Kasargod	Jun :20th:Kudulu-17; 20th:Kudulu-31, Hosdurg-28; 23rd:Hosdurg –14 Aug :10th:Hosdurg – 22 , Kudulu – 13 , Sep :26th:Hosdurg - 13
Idukki	Jul :19th:Peermade-15,Idukki-12,Thodupuzha-12 Aug :08th:Munnar Kseb-19, Peermade-19, 09th:Munnar KSEB-21, Idukki-19, Myladumpara_agri –17; 14th:Peermade-15
Malappuram	Jul :19th:Ponnani-14, Karipur AP-12 ; 20th:Ponnani–13 Aug :07th:Angadippuram – 13, Karipur AP – 12,Perinthalmanna–12; 09th:Manjeri-23, Perinthalamanna-21, Nilambur-19 , KaripurAp – 15; 10th: Karipur Ap. – 17 ,Perinthalamanna – 16 , Manjeri – 14; 11th:Perinthamanna-14, Ponnani-13, Karipur AP-13, Manjeri-13; 30th:Ponnani-12
Kottayam	Jul :19th:Kanjirapally-12 Aug :08th:Kanjirapally-12
Thrissur	Jul :19th:Chalakudy-12 Aug :06th:Chalakkudi –15; 07th:Chalakkudi - 12; 09th:Chalakudi-22, Kodungallur – 19 , Vellanikkara–15 ; 11th:Kodungallur-19, Chalakudi-12; 14th:Chalakudi-17, Enamackel-12
Kannur	Jul :20th:Kannur-22, Tellicheri-19, Taliparamba-17 Aug :08th:Irikkur-16; 09th:Tellicheri-20 ; 10th:Irikkur – 21 , Tellichery – 15 , Kannur - 14
Mahe	Jul :20th:Mahe-21 ; Aug :10th:Mahe - 18
Wayanad	Aug :07th:Vythiri –17; 08th:Manantoddy-26, Vythiri-24, Kuppady-19,Ambalavayal-12; 09th:Ambalavayal-26 ; 10th:Vyttiri – 21 , Ambalavayal - 17;

Palakkad	Aug :07th:Ottapalam –12; 09th:Alathur-40, Ottapalam-34, Kollamkode-32, Palakkad-29, Pattembi-23, Thritla-21 ; 10th:Ottapalam – 29 , Pattembi–18 ,Alathur – 12; 11th:Ottapalam-13 Sep :05th:Ottappalam-15
Alapuzha	Aug :14th:Cherthala-13
Lakshadweep	
Lakshadweep	Jul :18th: Amini - 14 Aug :14th: Agathi - 12

Legend: *Very heavy* rain (12-20 cm/day); *Extremely heavy* rain (≥21 cm/day)

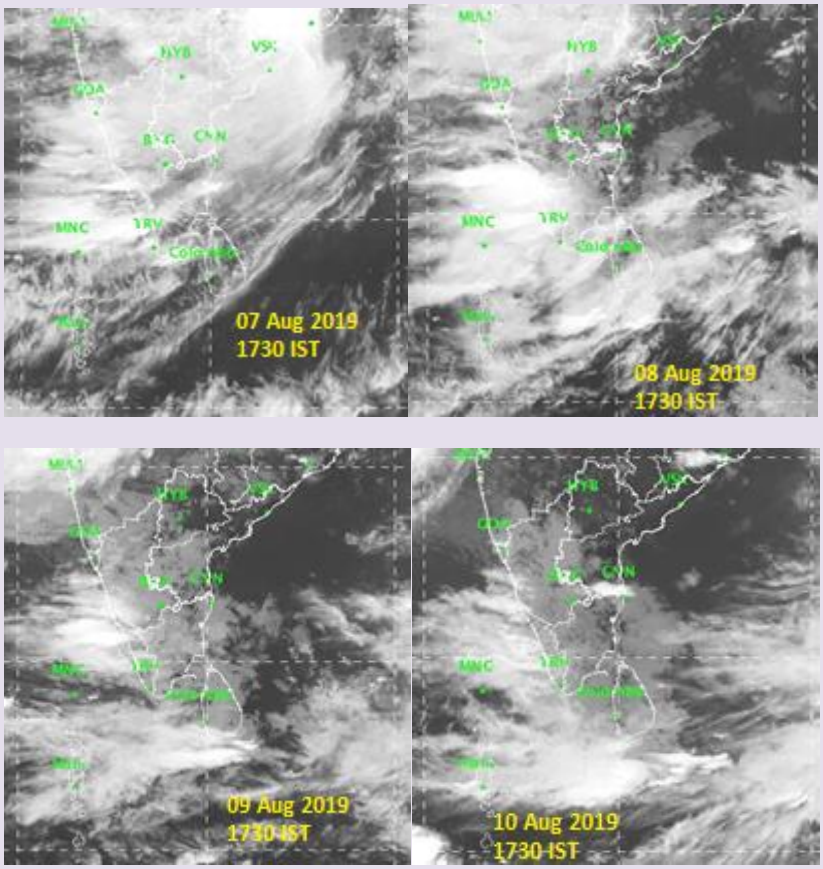


Fig.6a:INSAT-3D infra red imageries depicting cloudiness associated with intense rainfall activity during 7th-10th August 2019 over the SP region

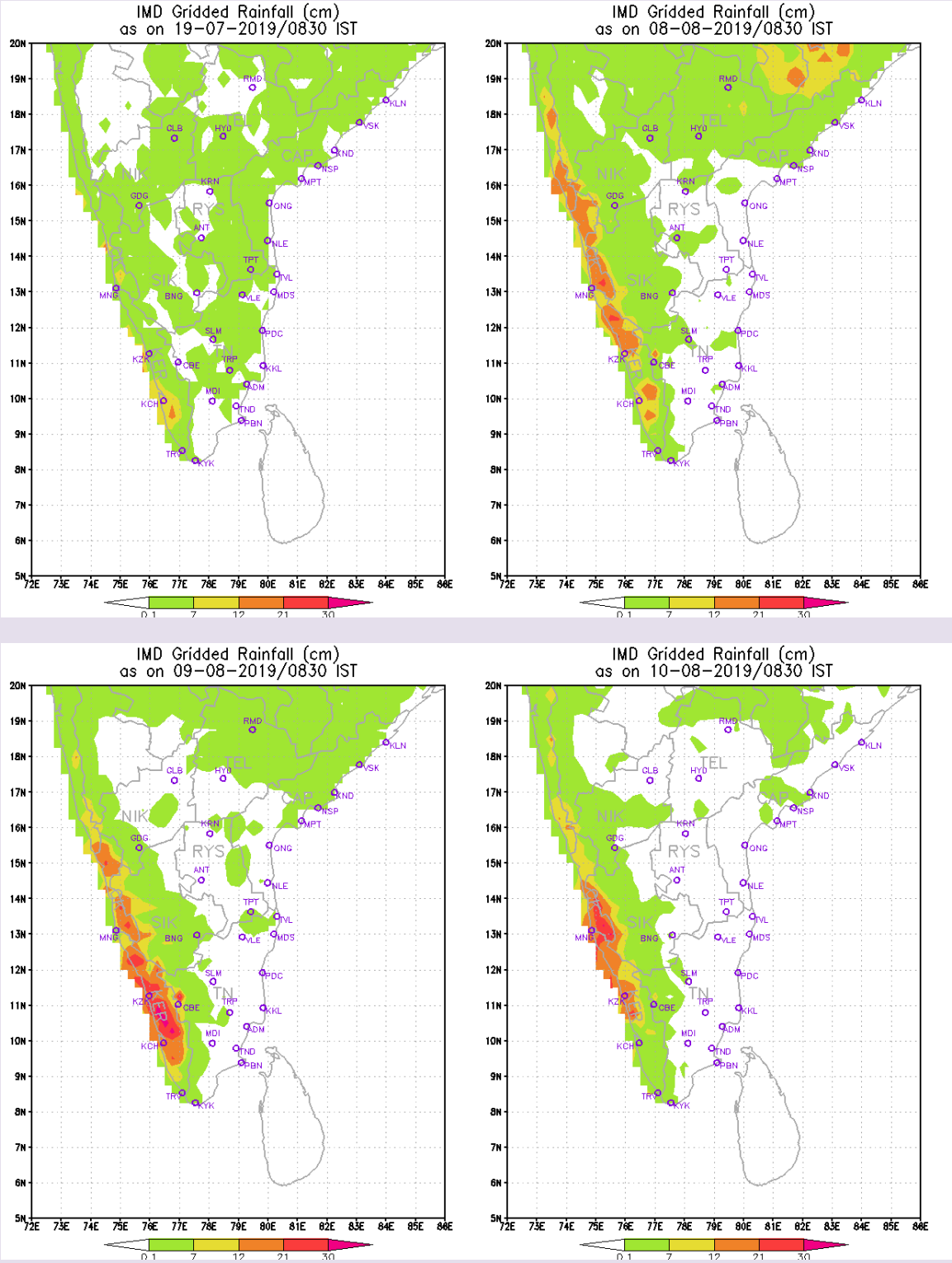


Fig.6b: IMD Gridded rainfall in cm depicting the spatial distribution of heavy rainfall activity on 19th July and 8th-10th Aug 2019 over the SP region

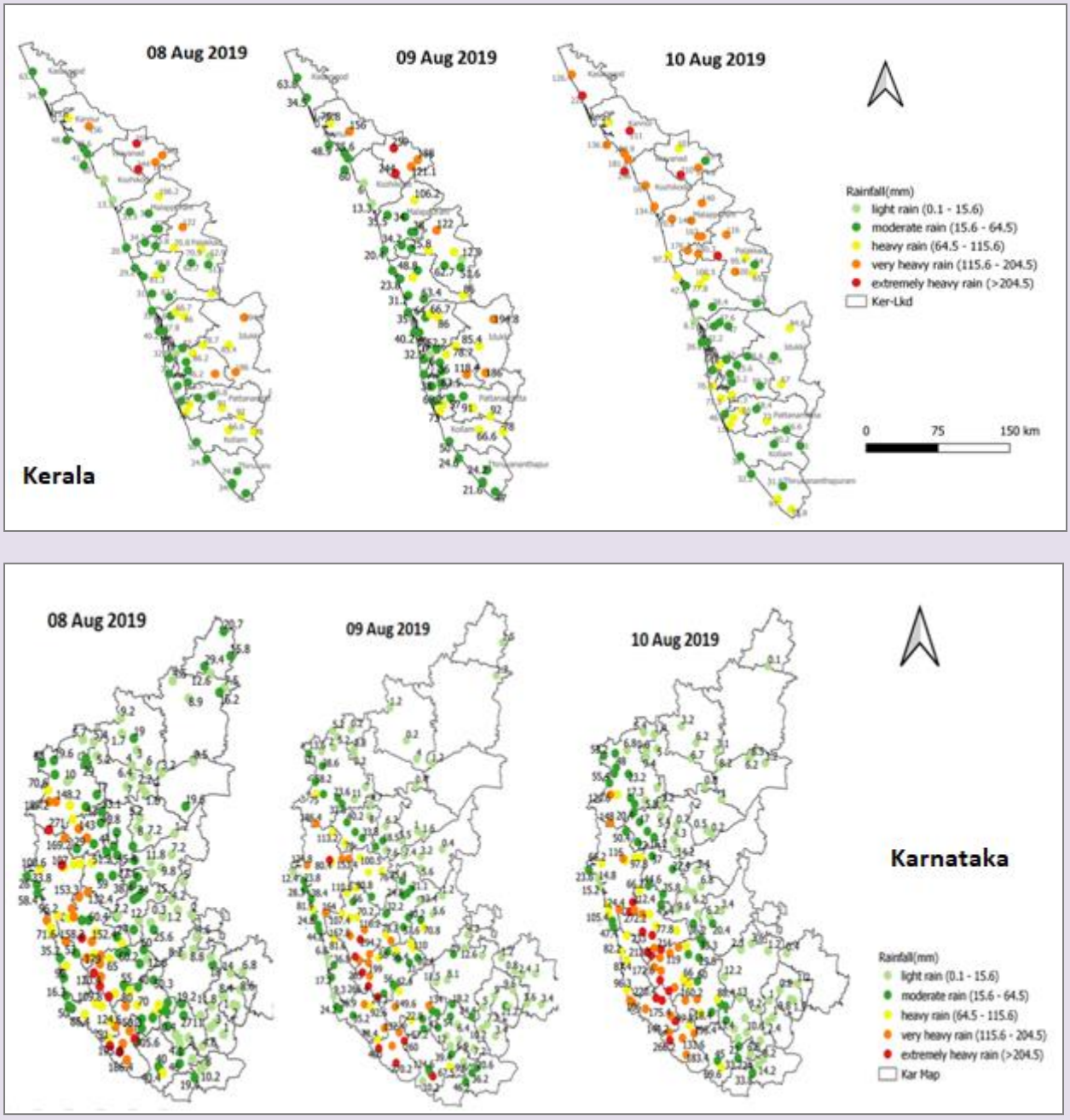


Fig.6c: Gauge observed rainfall (mm) depicting the spatial distribution of heavy rainfall activity during 8th-10th Aug 2019 over Kerala, Karnataka and Tamil Nadu

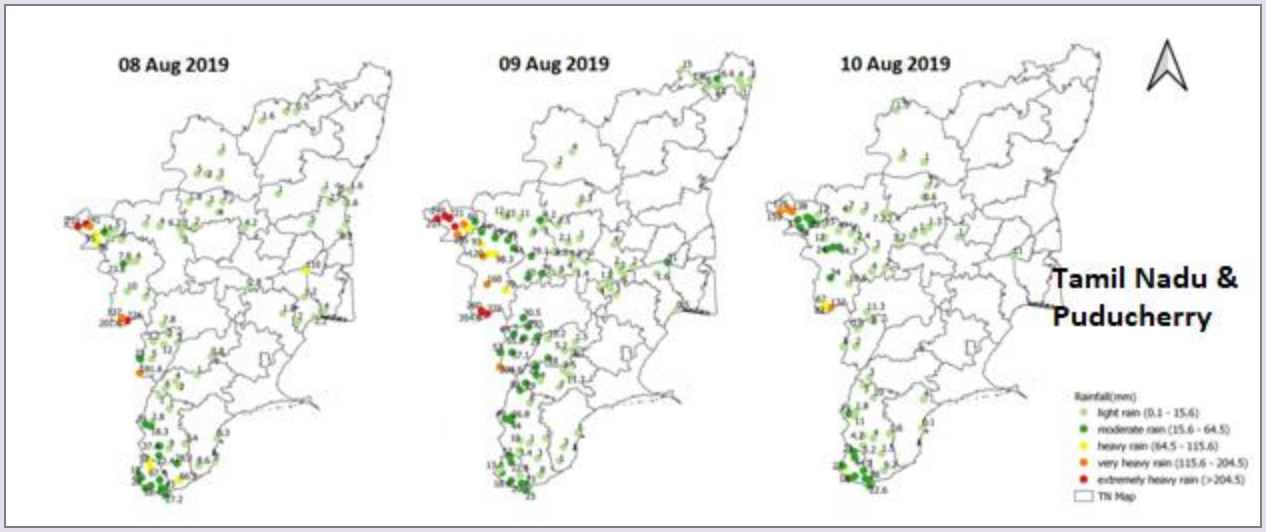


Fig. 6c(contd.)

2.7 Dry and Wet conditions

Based on Standardized Precipitation Index (SPI), a widely accepted index used for drought monitoring world-wide, based on rainfall, *mildly/moderately/severely/extremely dry* or *wet* situations over various districts of the region during June-Sep 2019 are depicted in Fig.7. The SPI indicates generally wet conditions over most districts of the SP region (*mildly/ moderately/ severely/ extremely wet* category).

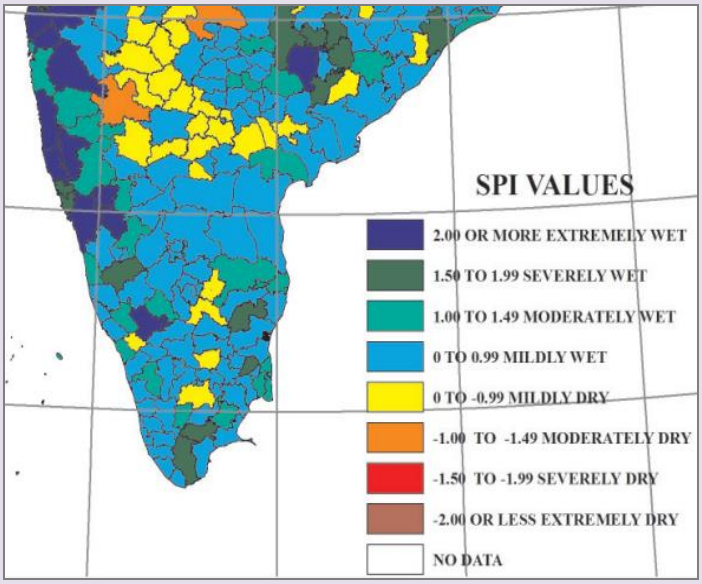


Fig.7: Standardised Precipitation Index (SPI) over the SP region for Jun-Sep 2019

2.8 Chief synoptic features

Monthly features: Fig.8a depicts the 850, 500 and 250 hPa wind anomaly during the months of June, July August and September 2019.

It is observed that in June, at 850 hPa level, anomalous easterlies prevailed over the peninsula indicating weak monsoon current. At 500 hPa level, anomalous anticyclonic circulation was observed over the central parts and the adjoining region.

In July, at 850 hPa level, anomalous westerlies prevailed over peninsular and central India. The anomalous westerlies extended upto 500 hPa over central Indian region.

In August, at 850 hPa level, anomalous westerlies over the peninsula and anomalous easterlies over northern parts indicating presence of active monsoon trough were observed. These anomalous circulation features extended up to 500 hPa level also.

In September, wind anomaly at 850 hPa level shows strong anomalous low level jet and strong cross equatorial flow in the month of September. This circulation extended up to 500 hPa level as well. At 200 hPa level, stronger than normal tropical easterly jet was observed.

Daily synoptic situations: In the daily scale, off-shore trough at mean sea level along the west coast of peninsular India, upper air cyclonic circulations over the various parts of the SP region and over Bay of Bengal and neighbourhood, east-west shear zone in the lower-mid troposphere running along the 10-18°N latitudes, low pressure areas that formed over West Central and adjoining North Bay of Bengal off Odisha - Andhra Pradesh coast with their associated upper air cyclonic circulation extending up to mid tropospheric levels tilting southwest-wards with height, troughs on sea level chart that ran from SIK to Tamil Nadu / Comorin area across interior Tamil Nadu and troughs in the monsoon westerlies in the lower tropospheric levels were associated with rainfall activity over the SP region.

The intense rain spell during 6-11 August 2019 over Kerala, Karnataka and TN was associated with strong pressure gradient, well marked offshore trough, strong monsoon westerlies and upper air cyclonic circulation in the upper troposphere. The mean sea level isobaric analysis as on 08 Aug 2019, 0830 IST and 1730 IST indicating strengthening of pressure gradient and offshore trough is presented in Fig.8b(i). Fig.8b(ii a&b) presents the upper air streamline analysis as on 08 Aug 2019 at 0830 IST and 1730 IST. It is observed an upper air cyclonic circulation prevailed in the upper troposphere at 7.6 km a.s.l. Aside from that, Orography enhanced the monsoon activity.

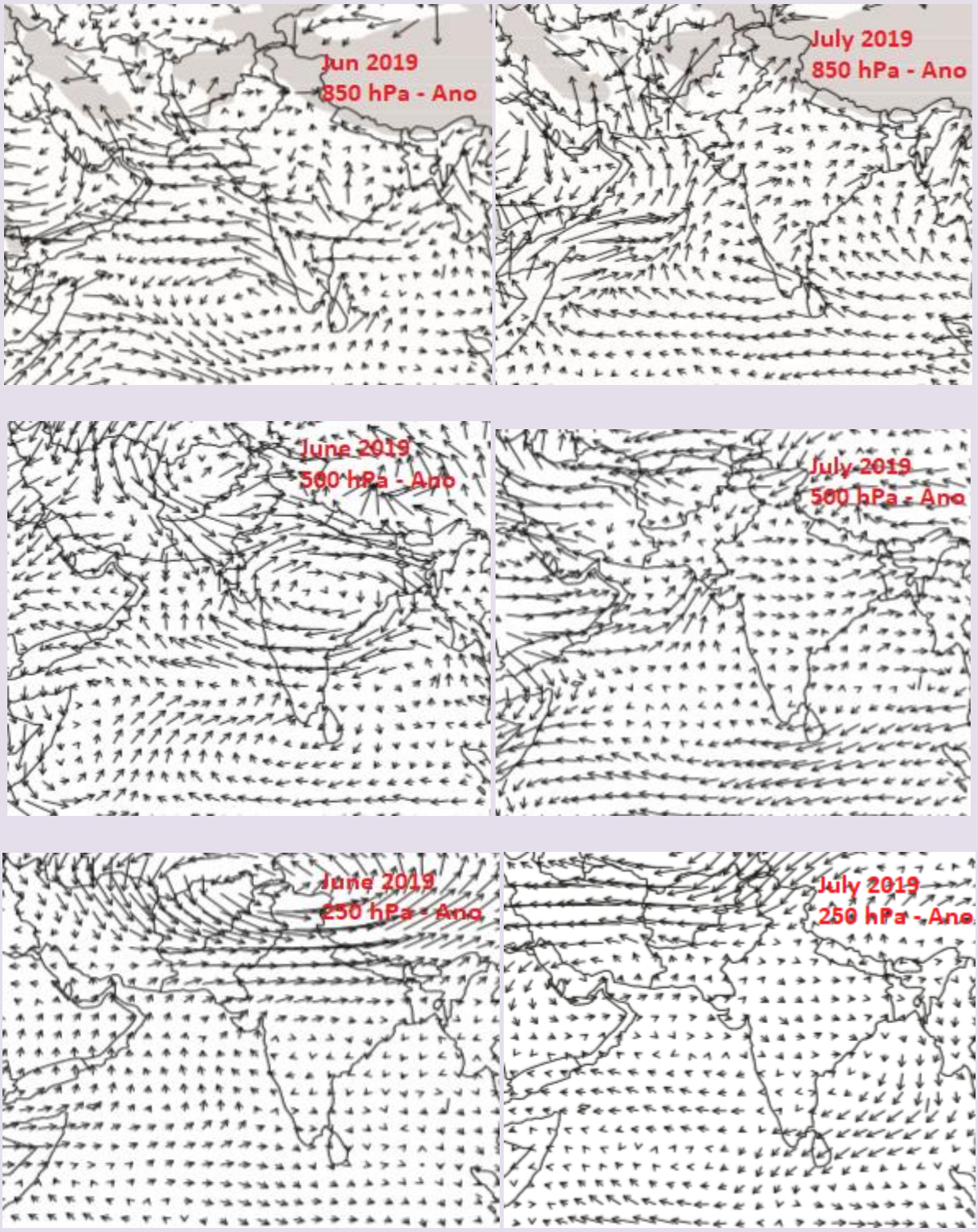


Fig.8a: 850hPa, 500 hPa& 250 hPa wind anomalies over Indian region during SWM 2019
(Source: Climate Diagnostic Bulletin of India, IMD Pune)

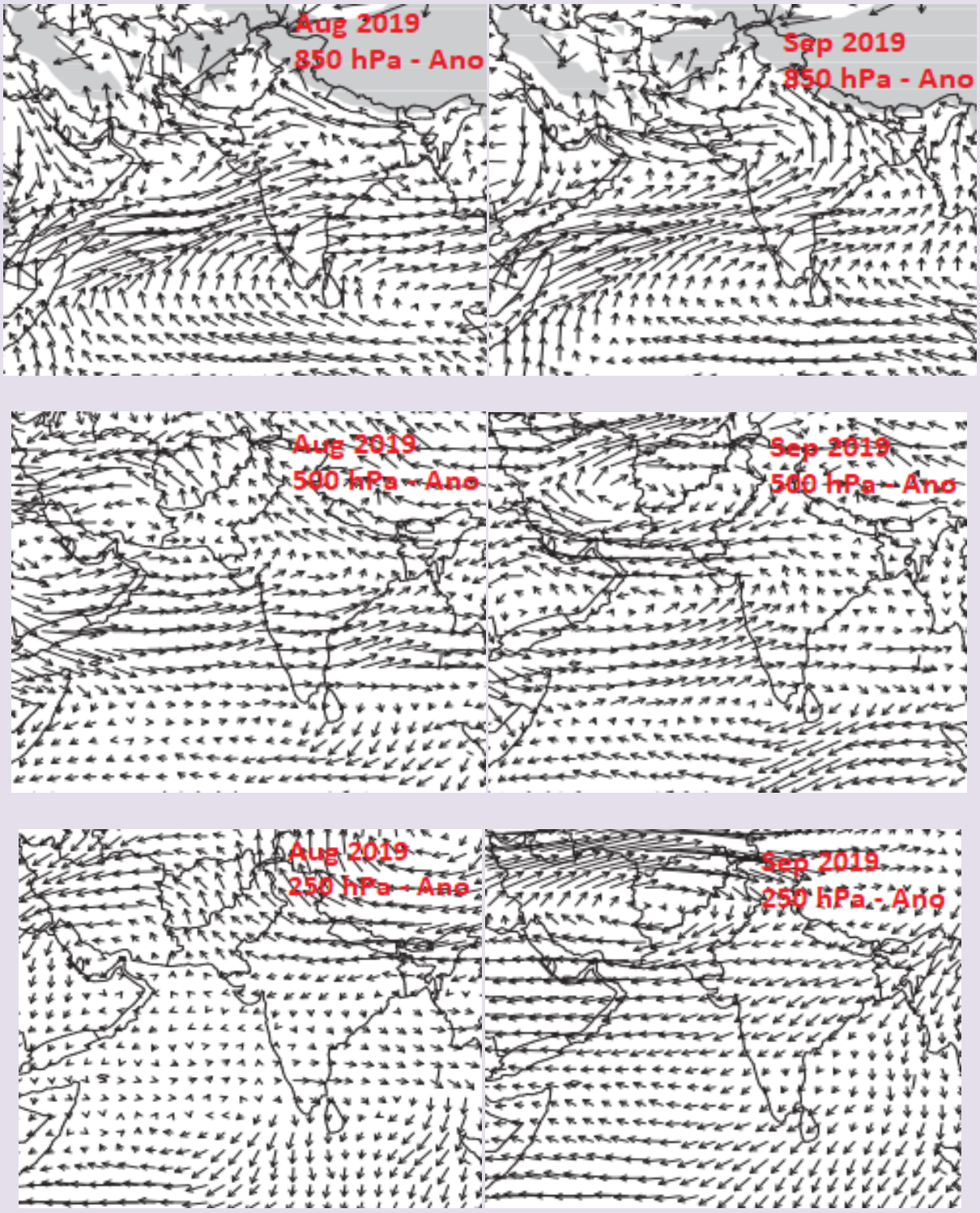
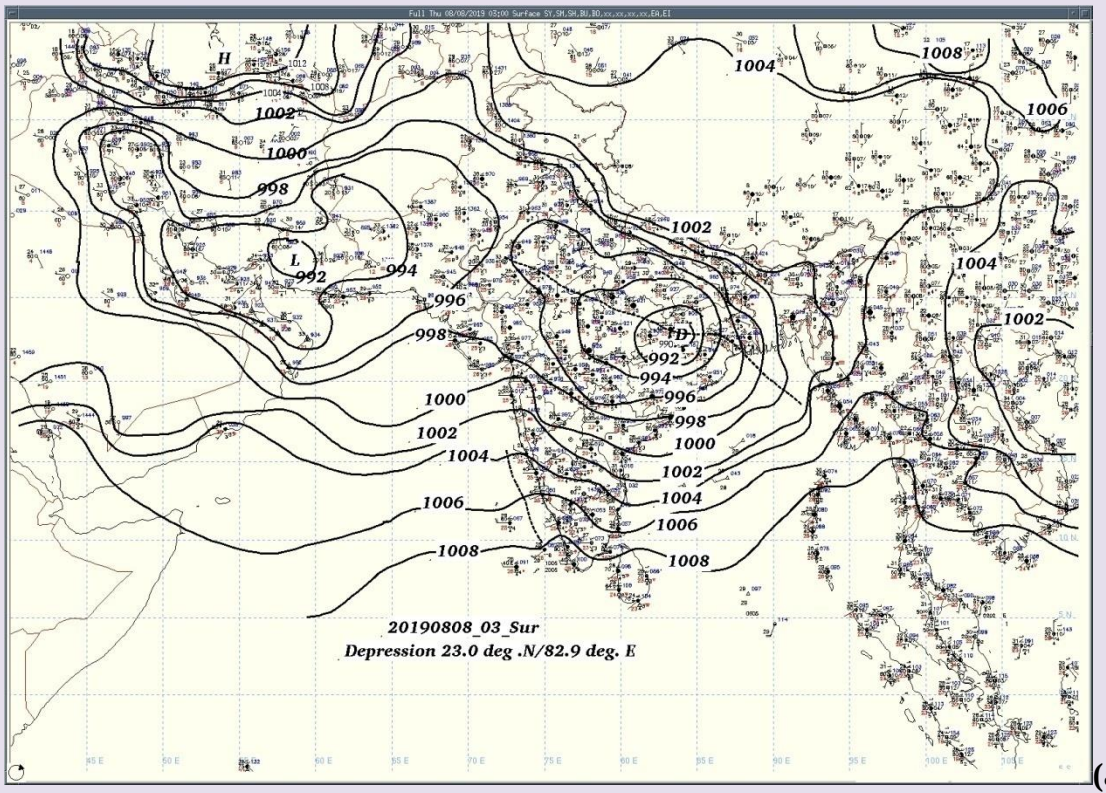
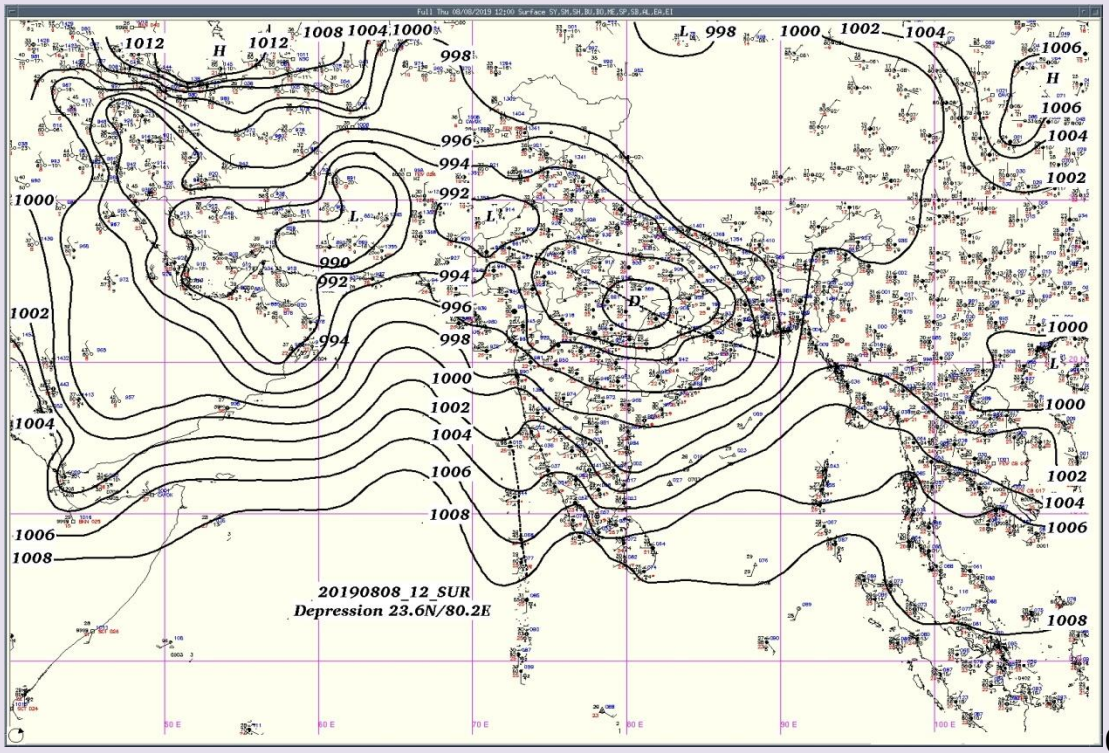

Aug 2019
850 hPa - Ano
Sep 2019
850 hPa - Ano
Aug 2019
500 hPa - Ano
Sep 2019
500 hPa - Ano
Aug 2019
250 hPa - Ano
Sep 2019
250 hPa - Ano

Fig.8a (contd.)

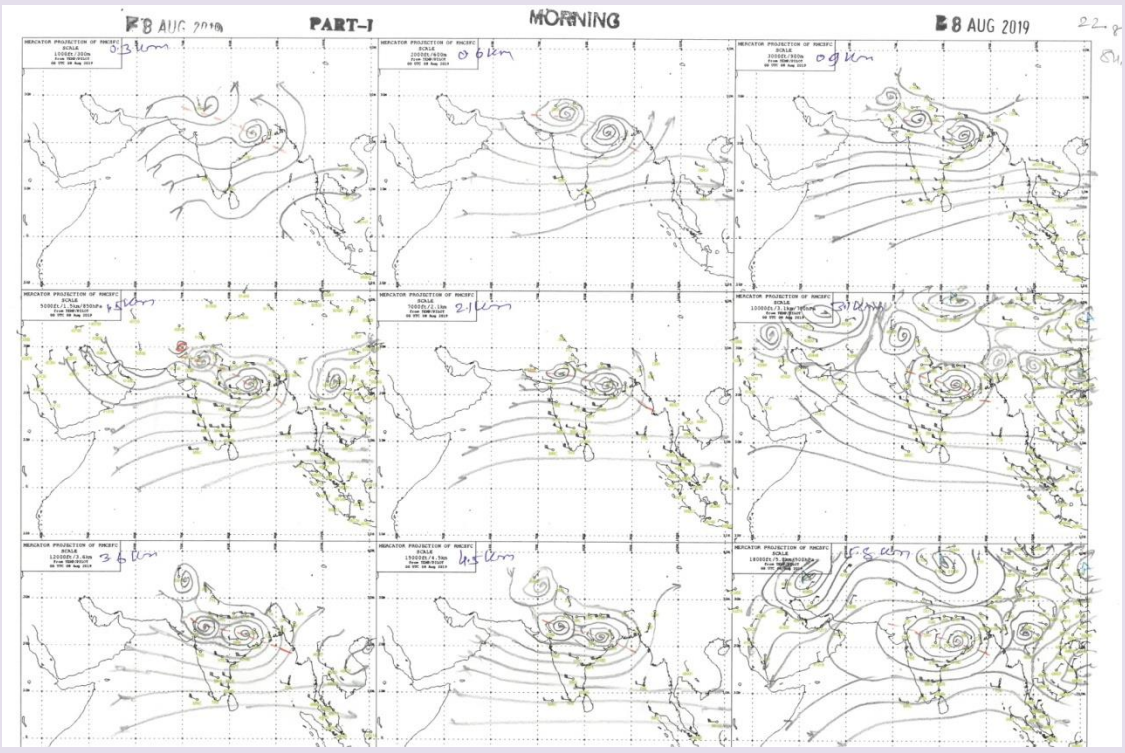


(a)



(b)

Fig.8b (i) Mean sea level pressure analysis chart based on 08/08/2019 (a) 0830 IST and (b) 1730 IST



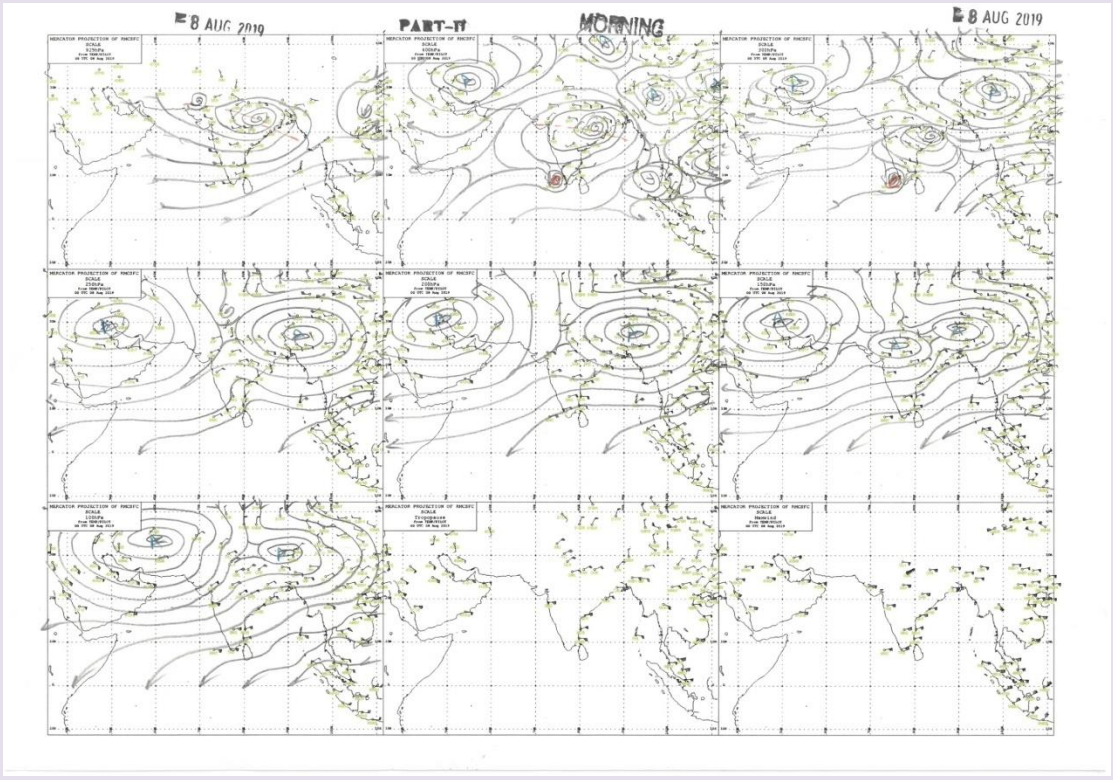
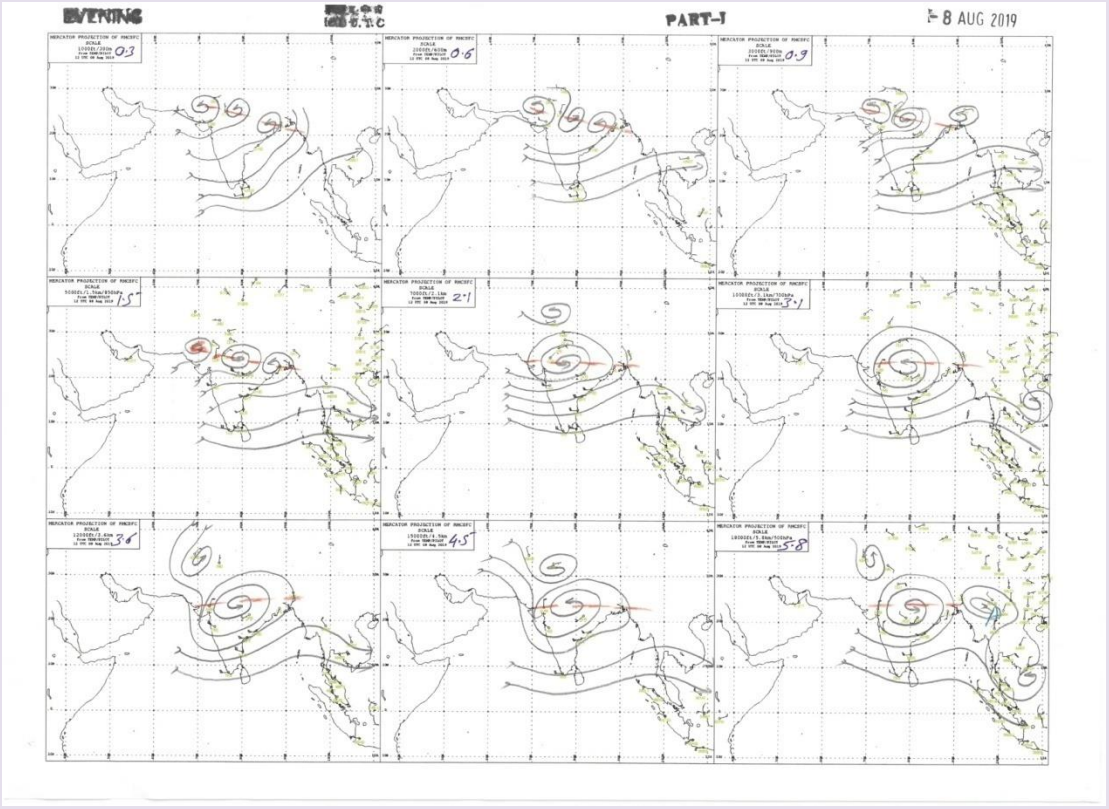


Fig.8b (ii -a) Upper air streamline analysis as on 08/08/2019, 0830 IST



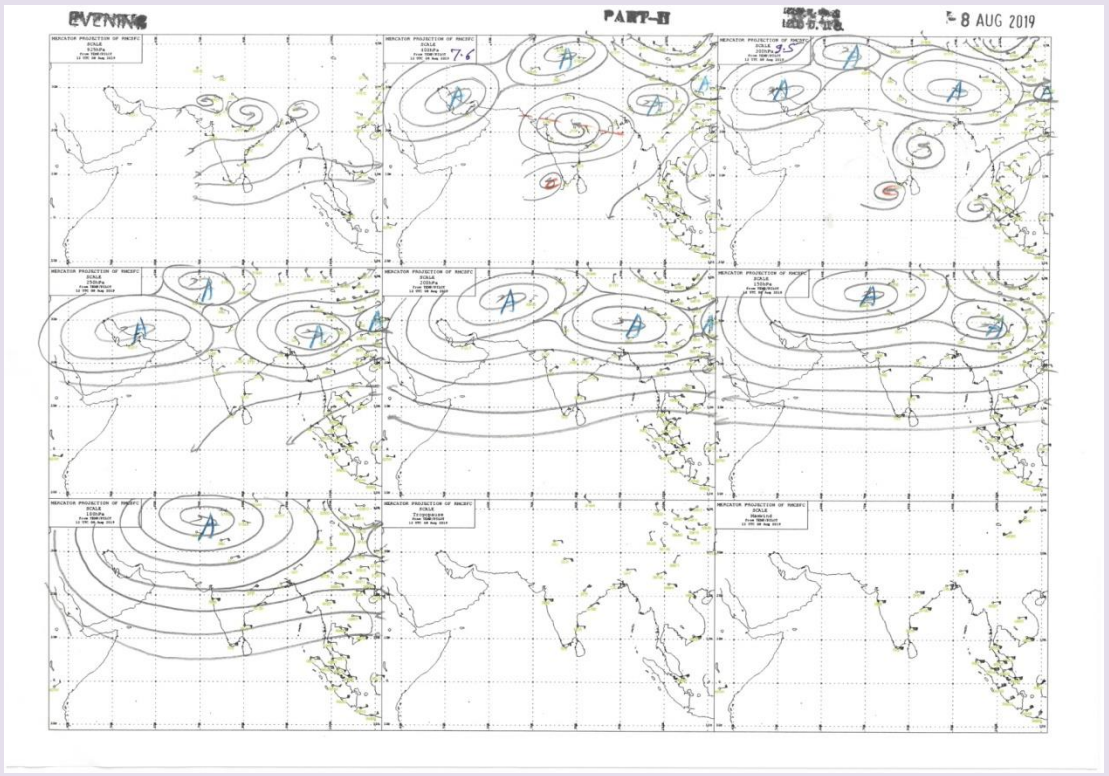


Fig.8b (ii -b) Upper air streamline analysis as on 08/08/2019, 1730 IST

Chief synoptic scale systems: During the period June-September 2019, four major synoptic scale systems formed over the North Indian Ocean. The first one was the VSCS "VAYU" during 10 -17 June over the AS that led to low level easterly anomalies over the peninsular region that weakened the monsoon current during the onset phase. The second system was a deep depression during 6 -9 August that formed over the Bay of Bengal and moved across the central India. Associated with the passage of this system, CAP and TEL received isolated very heavy to extremely heavy rainfall on 07th August. On 08th August also, TEL received isolated very heavy to extremely heavy rainfall. The third system was a VSCS "HIKAA" over the Arabian Sea during 22 – 25 September and the fourth system was a depression over Arabian Sea during 29 September - 1 October. The tracks of the above four systems are shown in Fig.8c. Aside from these systems, two more well marked low pressure areas that formed over the BOB– one in July and another in August caused weather over the northern parts of the SP region.

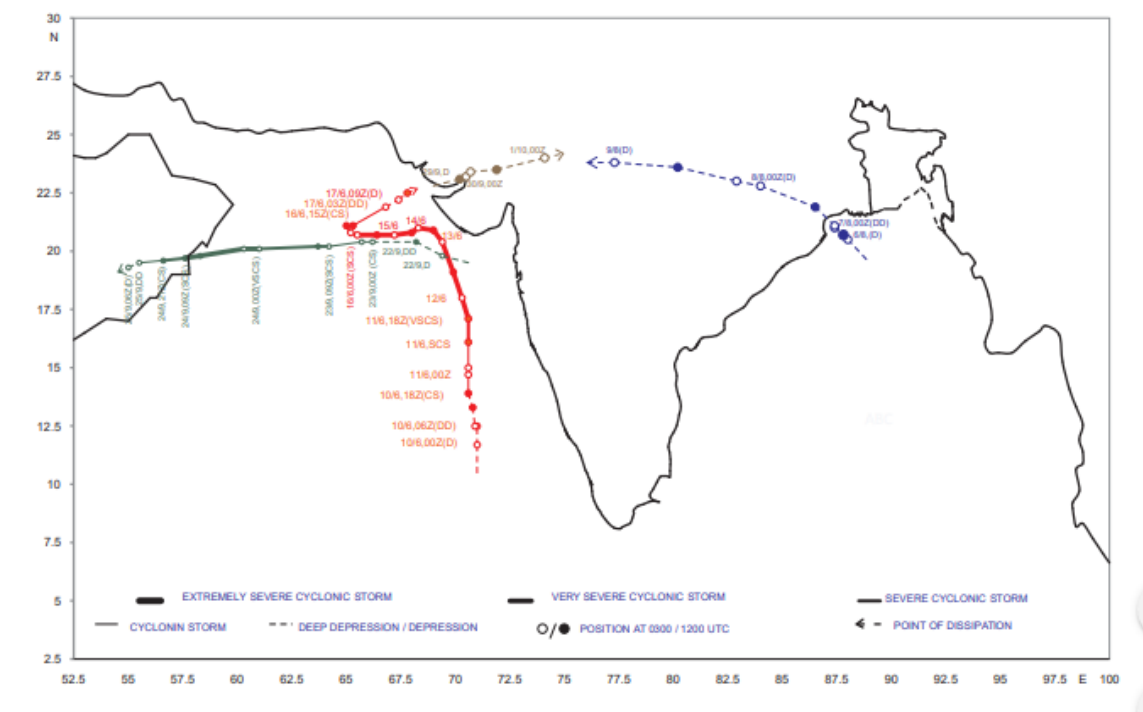


Fig.8c: Tracks of depressions and cyclonic storms during Jun-Sep 2019

3. Withdrawal of SWM 2019 from the SP region

The withdrawal of SWM 2019 commenced from the northwest India on 09th October only, a delay by more than a month (normal date – 1st September). Withdrawal of SWM 2019 from the SP region took place during 15-16 October 2019. Fig.9 depicts the withdrawal of SWM 2019 from the SP region.

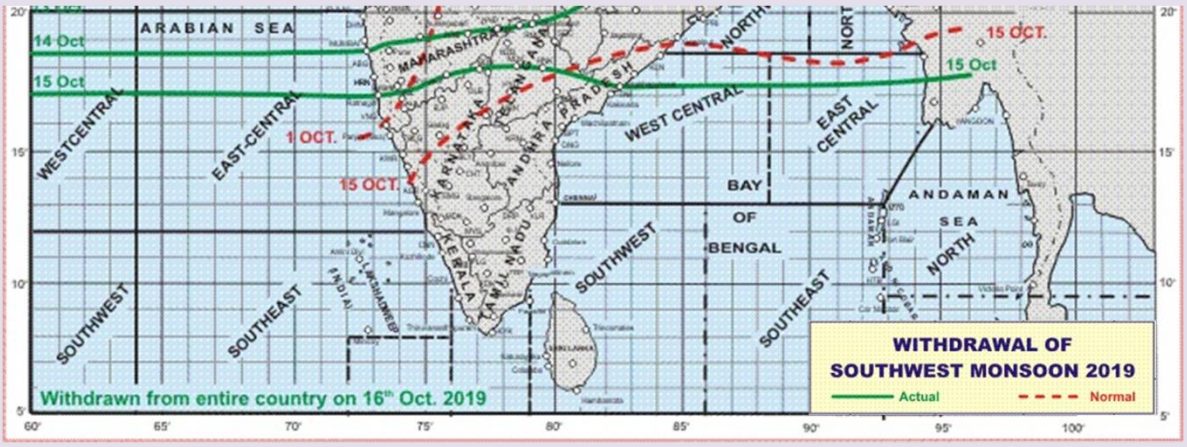


Fig.9: Isolines of dates of withdrawal of SWM 2019 over the SP region

4. Summary

During 2019, the southwest monsoon advanced over Andaman Sea on 24th May. The onset of the monsoon over Kerala took place on 08th June, 7 days later than the normal date of 1st June. It covered the entire southern peninsular India by 22ndJune. It covered the entire country on 19th July. Rainfall during the monsoon season of June-September 2019 over the southern Indian peninsular region comprising of the five states of Andhra Pradesh, Telangana, Karnataka, Kerala and Tamil Nadu and two union territories of Puducherry and Lakshadweep was 840.9 mm which is 15.8% more than its long period average of 726.2 mm. Seasonal rainfall over the nine meteorological subdivisions covering the five states and two union territories in the region was excess in four sub divisions [Coastal Karnataka, North Interior Karnataka, South Interior Karnataka and Lakshadweep]and normal in 5 sub divisions – Kerala and Mahe; Tamil Nadu, Puducherry and Karaikal; Coastal Andhra Pradesh and Yanam; Rayalaseema and Telangana. In

the monthly scale, rainfall was generally deficient in June. The rainfall activity gradually picked up in July. In August and September, all sub divisions in the SP region received *normal* to *excess* rainfall. Under the influence of stronger than normal southwesterlies in the lower-mid tropospheric levels over the peninsular region coupled with orographic effect recurrent heavy rainfall activity occurred over Kerala, Karnataka and adjoining hilly regions of Tamil Nadu in the second week of August causing inland flooding in many areas. The monsoon withdrew from the SP region during 15th-16th October 2019. It's withdrawal from the entire country was on 16th October with the simultaneous commencement of northeast monsoon rains over Tamil Nadu, Kerala and adjoining areas of Andhra Pradesh and Karnataka on 16th October 2019.

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 various state governments. 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

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

FWS- 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.		