

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



## REGIONAL REPORT ON SOUTHWEST MONSOON - 2018 OVER THE SOUTHERN PENINSULAR INDIA







**Regional Meteorological Centre, Chennai** 

## HIGHLIGHTS

✓ During 2018, southwest monsoon reached parts of south Bay of Bengal, south Andaman Sea and Nicobar islands on  $25^{\text{th}}$  May. It advanced over Kerala on  $29^{\text{th}}$ May, 3 days prior the normal date of  $1^{\text{st}}$  June and covered the entire southern peninsular India by  $9^{\text{th}}$  June.

✓ Rainfall during the SWM season of June-September 2018 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 704.4 mm which is 98% of its long period average (LPA) of 716.1 mm even though the SWM seasonal rainfall over the country as a whole was 91% of its LPA.

✓ Seasonal rainfall over the nine meteorological subdivisions covering the five states and two union territories in the region was excess in one sub division (Kerala), normal in 5 sub divisions (CK, SIK, TN, CAP & TEL) and deficient in 3 sub divisions (LAK, NIK & RYS). The seasonal rainfall figures over the nine subdivisions CAP, RYS, TEL, TN, CK, NIK, SIK, KER, LAK) were 0%,-37%, -2%, -12%, -1%, -29%, +4%, +23%, and -45% respectively.

✓ In the monthly scale, the sub division of LAK came under *deficient* category and TN, under *normal* rainfall category, during all the four months (Jun-Sep) of the season. Excepting the month of June, when RYS & NIK came under *normal* rainfall category, these two sub divisions became *deficient* – *large deficient* during the other three months of the season (July, Aug & Sep). The other five sub divisions of CAP, TEL, CK, SIK & KER received *normal* - *excess* rainfall in June and July. In August, all these five sub divisions received *excess* rainfall with KER coming under *large excess* category (+96%). However, in September, all these five sub divisions ended up *deficient* - *large deficient* with CK & KER recording *large deficiency*.

 $\checkmark$  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 in August. Kerala experienced unprecedented floods in the month of August.

✓ The withdrawal of SWM 2018 from the SP region commenced on  $05^{\text{th}}$  October. It withdrew from the entire region on  $21^{\text{st}}$  October 2018.

### 1. Onset and Advance

During the year 2018, 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 25<sup>th</sup> May. The Arabian Sea (AS) branch of the SWM current, which leads to the onset of SWM over Kerala, advanced over Kerala on 29<sup>th</sup> May 2018, 3 days ahead of the normal date of onset over Kerala on 1<sup>st</sup> 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 (CAP), Telangana (TEL), Rayalaseema (RYS), Tamil Nadu & Puducherry (TN), Coastal Karnataka (CK),North Interior Karnataka (NIK), South Interior Karnataka (SIK), Kerala (KER) and Lakshadweep (LAK) - by 9<sup>th</sup> June against the normal date of 10<sup>th</sup> June.

During the onset phase of the monsoon over Kerala, widespread rainfall occurred over Kerala from 25<sup>th</sup> May onwards. Westerly/southwesterly wind over south Arabian Sea strengthened and deepened upto 600 hPa level on 29<sup>th</sup> May. East-west shear zone running across south peninsula (roughly along 12<sup>o</sup>N latitude) at 3.1 km above mean sea level and a well-marked low pressure area over southeast and adjoining east-central AS off north Kerala – Karnataka coasts were associated with the onset of SWM over Kerala and adjoining areas on 29<sup>th</sup> May.

On 29<sup>th</sup> May, the SWM covered the LAK islands, most parts of Kerala and some parts of Tamil Nadu. On 30<sup>th</sup> May, it further advanced into the remaining parts of Kerala, some parts of Karnataka and some more parts of TN. It further advanced into some more parts of TN on 3<sup>rd</sup> June. By 6<sup>th</sup> June, it further advanced into some parts of Karnataka, the remaining parts of TN, most parts of RYS and some parts of CAP. By 8<sup>th</sup> June, it further advanced into the remaining parts of Karnataka, remaining parts of RYS, entire TEL and most parts of CAP. On 9<sup>th</sup> June, it further advanced into the remaining parts of CAP and covered the entire region. As such, it took 12 days for the monsoon to cover the entire SP region. Fig.1a depicts the progression of the northern limit of monsoon (NLM: A line delineating the regions where the monsoon has advanced from the regions where the monsoon is yet to advance into) over the region and Fig.1b

presents the INSAT-3D satellite imageries depicting the cloudiness associated with the onset of SWM over Kerala on 29<sup>th</sup>May and its further advance into the SP region by 9<sup>h</sup> June 2018. Fig.1c presents GPM satellite+ gauge merged rainfall depicting the advance of SWM 2018 over the SP region.



Fig.1a Advance of southwest monsoon 2018 over southern peninsular India depicted by lines of northern limit of monsoon on various dates



Fig.1b INSAT-3D infra-red imageries as on 27<sup>th</sup> & 29<sup>th</sup> May, 03<sup>rd</sup>, 06<sup>th</sup> & 09<sup>th</sup> June 2018 depicting the advance of SWM 2018 over the SP region



(Fig.1b contd...)



Fig.1c GPMsatellite-Gauge merged 24-hr rainfall in cm as on 0300 UTC (0830 IST) of 29<sup>th</sup> & 30<sup>th</sup> May, 02<sup>nd</sup>, 04<sup>th</sup>, 07<sup>th</sup> and 09<sup>th</sup> June 2018 depicting the advance of monsoon rains over the SP region during SWM 2018



### 2. Rainfall distribution

#### 2.1 Seasonal sub divisional rainfall

The SWM seasonal rainfall (June-September) during 2018 over the country as a whole was 91% of its long period average (LPA) and that over the SP region was 98% 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 2018, in the SP region, one sub division, Kerala, received *excess* rainfall, five subdivisions (CAP, TEL, TN, CK & SIK) received *normal* rainfall and the other three sub divisions (RYS, NIK & LAK) ended up deficient. The cumulative seasonal (01<sup>st</sup> June to 30<sup>th</sup>)

Sep) rainfall figures for the nine meteorological sub divisions of the SP region are furnished in Table-1 and Fig.2.

 Table-1: Seasonal subdivisional rainfall distribution over the SP region during the SWM season, 2018 (01<sup>st</sup> June-30 Sep 2018)

SUB-DIVISION	Actual	Normal	Percentage
	rainfall	rainfall	departure from
	(mm)	(mm)	normal (%)
COASTAL ANDHRA PRADESH (CAP)	581.2	581.1	0
TELANGANA (TEL)	742.4	759.2	-2
RAYALASEEMA (RYS)	252.6	398.3	-37
TAMIL NADU & PUDUCHERRY (TN)	283.0	321.4	-12
COASTAL KARNATAKA (CK)	3061.6	3083.5	-1
NORTH INTERIOR KARNATAKA (NIK)	357.6	506	-29
SOUTH INTERIOR KARNATAKA (SIK)	687.4	659.9	4
KERALA (KER)	2517.2	2039.6	23
LAKSHADWEEP (LAK)	553.2	998.4	-45



Largely	Deficient	Normal	Excess	Large
Deficient				Excess
<b>≤ -60%</b>	-20% to -59%	-19% to +19%	+20% to +59%	≥+60%

Fig.2 Sub divisional seasonal rainfall (percentage departures from normal) during Jun-Sep 2018 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 2018, the sub division of LAK came under *deficient* category and TN, under *normal* rainfall category, during all the four months (Jun-Sep) of the season. Excepting the month of June, when RYS & NIK came under *normal* rainfall category, these two sub divisions became *deficient* – *large deficient* during the other three months of the season (July, Aug & Sep). The other five sub divisions of CAP, TEL, CK, SIK & KER received *normal* - *excess* rainfall in June and July. In August, all these five sub divisions received *excess* rainfall with KER coming under *large excess* category (+96%). However, in September, these five sub divisions ended up *deficient* - *large deficient* with CK & KER recording *large deficiency* of -70% and -64% rainfall respectively.

Sub-division		June			July			Aug			Sep	
	ACL (mm)	NOR (mm)	PDN (%)									
COASTAL ANDHRA PRADESH	108.9	103.9	5	172.1	160.4	7	205.4	157.7	30	94.7	159.1	-40
TELANGANA	170.1	136.2	25	197.5	240.9	-18	294.4	220.7	33	80.5	161.4	-50
RAYALASEEMA	64.7	67.7	-4	32.7	94.2	-65	52.8	103.3	-49	102.4	133.1	-23
TAMIL NADU & PUDUCHERRY	49.4	46.5	6	58.2	69.1	-16	71.7	88.7	-19	103.7	117.0	-11
COASTAL KARNATAKA	1011.2	867.7	17	1034.6	1159.7	-11	925.4	755.6	22	89.3	300.9	-70
NORTH INTERIOR KARNATAKA	107.8	104.6	3	88.2	134.8	-35	89.6	120.7	-26	69.8	145.8	-52
SOUTH INTERIOR KARNATAKA	181.7	141.5	28	196.7	216.1	-9	200.3	161.2	24	106.7	141.0	-24
KERALA	749.6	649.8	15	857.4	726.1	18	821.9	419.5	96	88.4	244.2	-64
LAKSHADWEEP	203.2	330.2	-38	151.2	287.7	-47	124.4	217.5	-43	74.4	163.1	-54

Table-2: Monthly sub divisional rainfall performance during SWM 2018

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

Largely	Deficient	Normal	Excess	Large
Deficient				Excess
≤ <b>-60%</b>	-20% to -59%	-19% to +19%	+20% to +59%	≥+60%



Fig.3 Monthly sub divisional rainfall distribution during Jun-Sep 2018

### 2.3 Weekly sub divisional rainfall progress

Week by week and cumulative weekly performance of SWM 2018 over the SP region are presented in Table-3a and Table 3b respectively.





Table-3b: Weekly cumulative sub divisional rainfall during Jun-Sep 2018



During the 18 weeks covering the SWM season of 2018, CK, KER & CAP recorded maximum number of *normal* to *excess* rainfall weeks (10 weeks). RYS recorded maximum number of *deficient* to *large deficient* weeks (15 weeks) followed by LAK (14 weeks). During the weeks ending 06<sup>th</sup> & 13<sup>th</sup> June, 11<sup>th</sup> & 18<sup>th</sup> July, 15<sup>th</sup> & 22<sup>nd</sup> Aug 6 or more sub divisions in the region recorded *normal* to *excess* rainfall. In the week ending 13<sup>th</sup> June, 8 out of the 9 sub divisions in the region recorded *excess* to *large excess* rainfall and in the week ending 15<sup>th</sup> Aug, these 8 sub divisions recorded *normal* to *large excess* rainfall. During the week ending 12<sup>th</sup> September, all the nine sub divisions in the region recorded *deficient* rainfall.

Considering the cumulative seasonal rainfall performance at the end of each week, it is noted that CAP, TEL, TN & SIK came under *normal* to *large excess* category and LAK came under *deficient* category throughout the season. From the 2<sup>nd</sup> week (week ending 13<sup>th</sup> June) onwards KER & CK also came under *normal* to *excess* category throughout. From the week ending 15<sup>th</sup> August onwards, Kerala came under *excess* category continuously even though it recorded *deficient* to *large deficient* rainfall during the five weeks covering the period 23<sup>rd</sup> August to 26<sup>th</sup> September. The *large excess* rainfall recorded during the week ending 15<sup>th</sup> August maintained the cumulative rainfall figures of Kerala at *excess* category since then throughout.

### 2.4 Daily sub divisional rainfall and monsoon activity

Table-4a presents daily spatial rainfall distribution over various sub divisions of the SP region during the SWM 2018 and Table-4b, the percentage frequency of various categories of spatial rainfall distribution over each sub division during the season. Whereas CK & KER experienced widespread rainfall on 77% & 60% of the days respectively, TN & RYS reported *isolated* rainfall activity on 76% and 65% of the days respectively. *Scattered* to *widespread* rainfall was realized over NIK, SIK & LAK on about 80% of the days and over CAP & TEL on about 50-60% of the days. The daily cumulative rainfall over all the sub divisions of the SP region was by and large near normal to slightly above normal on most of the days during the season (Fig.4)

Date as									
on 0830									
IST of	CAP	TEL	RYS	TN	СК	NIK	SIK	KER	LAK
1-Jun	ISOL	ISOL	ISOL	ISOL	SCT	FWS	SCT	SCT	FWS
2-Jun	ISOL	SCT	ISOL	ISOL	WS	FWS	WS	SCT	FWS
3-Jun	FWS	SCT	SCT	ISOL	SCT	FWS	FWS	FWS	FWS
4-Jun	ISOL	FWS	FWS	SCT	WS	WS	FWS	WS	WS
5-Jun	ISOL	ISOL	ISOL	ISOL	WS	ISOL	FWS	FWS	FWS
6-Jun	SCT	SCT	ISOL	ISOL	WS	FWS	SCT	FWS	SCT
7-Jun	FWS	WS	ISOL	SCT	WS	FWS	SCT	WS	WS
8-Jun	SCT	SCT	FWS	ISOL	WS	WS	WS	WS	WS
9-Jun	FWS	FWS	ISOL	ISOL	WS	FWS	WS	WS	WS
10-Jun	SCT	WS	SCT	ISOL	WS	FWS	WS	WS	WS
11-Jun	ISOL	WS	FWS	ISOL	WS	WS	WS	WS	FWS
12-Jun	SCI	FWS	ISOL	ISOL	VVS	FWS	FWS	VVS	FWS
13-Jun	SCI	SCI	ISOL	ISOL	VVS	ISOL	SCI	VVS	WS NVS
14-Jun	UKY	DRY	ISOL	ISOL	VVS	UKY	FVVS	VVS	VVS
15-Jun	ISOL	ISOL	ISOL	ISOL	VV.5	ISOL	FVVS	EWS	 
17-Jun	ISOL	ISOL	ISOL	SCT	W/S	ISOL	SCT	N/S	W/S
18-Jun	ISOL	ISOL	ISOL	ISOL	W/S	SCT	SCT	EW/S	FWS
19-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	WS	WS
20-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	WS	WS
21-Jun	ISOL	ISOL	ISOL	ISOL	WS	ISOL	SCT	WS	SCT
22-Jun	SCT	SCT	ISOL	ISOL	WS	SCT	SCT	WS	DRY
23-Jun	ISOL	WS	ISOL	ISOL	WS	FWS	SCT	WS	SCT
24-Jun	ISOL	ISOL	ISOL	ISOL	WS	SCT	FWS	WS	DRY
25-Jun	ISOL	ISOL	ISOL	ISOL	ws	SCT	SCT	WS	FWS
26-Jun	ISOL	ISOL	SCT	ISOL	WS	SCT	FWS	WS	ws
27-Jun	FWS	SCT	ISOL	ISOL	WS	SCT	FWS	WS	SCT
28-Jun	WS	WS	ISOL	ISOL	WS	FWS	WS	WS	WS
29-Jun	SCT	SCT	ISOL	ISOL	WS	SCT	SCT	WS	WS
30-Jun	SCT	SCT	ISOL	ISOL	WS	SCT	SCT	WS	WS
1-Jul	FWS	ISOL	ISOL	SCT	FWS	SCT	SCT	SCT	FWS
2-Jul	ISOL	ISOL	ISOL	SCT	WS	SCT	SCT	FWS	WS
3-Jul	FWS	SCT	SCT	FWS	WS	ISOL	FWS	WS	FWS
4-Jul	SCT	ISOL	ISOL	ISOL	WS	ISOL	SCT	SCT	DRY
5-Jul	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	ISOL	WS
6-Jul	SCT	WS	ISOL	ISOL	WS	FWS	SCT	FWS	WS
7-Jul	FWS	WS	SCT	ISOL	WS	FWS	FWS	WS	SCT
8-Jul	FWS	WS	SCT	ISOL	WS	FWS	WS	WS	FWS
9-Jul	FWS	WS	SCT	ISOL	WS	WS	WS	WS	WS
10-Jul	FWS	WS	FWS	SCT	WS	FWS	WS	WS	WS
11-Jul	FWS	SCI	SCI	SCI	WS	FWS	WS	WS	WS
12-Jul	SCT	W/S	SCT	ISOL	W/S	N/S	VV5	W/S	W/S
14-Jul	EWS	W/S	SCT	ISOL	W/S	EWS	W/S	W/S	EWS
14-Jul	14/5	W/S	ISOL	ISOL	W/S	EWS	14/5	W/S	W/S
16-Jul	EWS	EWS	ISOL	ISOL	WS	WS	EWS	WS	WS
17-Jul	EWS	EWS	ISOL	ISOL	WS	EWS	EWS	WS	WS
18-Jul	SCT	FWS	ISOL	ISOL	WS	FWS	FWS	WS	WS
19-Jul	ISOL	ISOL	ISOL	ISOL	WS	SCT	FWS	WS	WS
20-Jul	FWS	FWS	ISOL	ISOL	ws	FWS	FWS	ws	FWS
21-Jul	FWS	ws	ISOL	ISOL	ws	FWS	FWS	ws	ws
22-Jul	SCT	ISOL	ISOL	ISOL	ws	FWS	FWS	ws	DRY
23-Jul	ISOL	ISOL	DRY	ISOL	WS	SCT	FWS	WS	SCT
24-Jul	ISOL	SCT	ISOL	ISOL	WS	FWS	FWS	WS	SCT
25-Jul	ISOL	SCT	ISOL	ISOL	WS	SCT	FWS	WS	FWS
26-Jul	ISOL	ISOL	DRY	ISOL	WS	SCT	FWS	ws	FWS
27-Jul	ISOL	ISOL	ISOL	ISOL	ws	SCT	FWS	ws	FWS
28-Jul	SCT	ISOL	DRY	ISOL	ws	SCT	SCT	FWS	SCT
29-Jul	SCT	ISOL	DRY	ISOL	WS	SCT	SCT	WS	DRY
30-Jul	SCT	DRY	DRY	ISOL	WS	ISOL	ISOL	WS	SCT
21 1.1	ISOL	ISOL	DRY	ISOL	W/S	ISOL	SCT	W/S	DBY

## Table-4a: Daily sub divisional rainfall distribution over the SP region during SWM 2018

Date as									
on 0830									
IST of	CAP	TEL	RYS	TN	ск	NIK	SIK	KER	LAK
1-Aug	ISOL	ISOL	ISOL	ISOL	ws	SCT	FWS	WS	FWS
2-Aug	SCT	FWS	ISOL	ISOL	WS	SCT	FWS	WS	DRY
3-Aug	SCT	SCT	ISOL	ISOL	WS	SCT	SCT	WS	SCT
4-Aug	ISOL	ISOL	ISOL	ISOL	WS	SCT	SCT	WS	SCT
5-Aug	ISOL	SCT	SCT	ISOL	WS	FWS	SCT	FWS	DRY
6-Aug	ISOL	ISOL	SCT	ISOL	WS	SCT	SCT	WS	FWS
7-Aug	FWS	SCT	ISOL	ISOL	WS	FWS	FWS	WS	SCT
8-Aug	FWS	FWS	SCT	ISOL	WS	FWS	FWS	WS	FWS
9-Aug	SCT	SCT	ISOL	SCT	WS	FWS	FWS	WS	DRY
10-Aug	SCT	FWS	ISOL	ISOL	WS	SCT	FWS	WS	FWS
11-Aug	FWS	WS	FWS	SCT	WS	FWS	FWS	WS	FWS
12-Aug	FWS	WS	SCT	ISOL	WS	WS	WS	WS	FWS
13-Aug	FWS	FWS	SCT	ISOL	WS	WS	WS	WS	FWS
14-Aug	WS	FWS	ISOL	ISOL	WS	FWS	WS	WS	SCT
15-Aug	WS	SCI	FWS	FWS	WS	WS	WS	WS	WS
17 Aug	VVS ECT	WS	VVS	SCI	VVS	VVS	VVS	WVS	VVS
18-Aug	SCT	EWS	ISOL	ISOL	WS	SCT	EVVS	10/5	10/S
19-Aug	SCT	EW/S	ISOL	ISOL	WS	SCT	10/5	10/5	WS
20-44	WS	W/S	ISOL	ISOL	WS	SCT	EW/S	WS	W/S
21-Aug	EWS	WS	ISOL	ISOL	WS	WS	FWS	WS	SCT
22-Aug	ISOL	ISOL	ISOL	ISOL	ws	ws	ws	ws	ws
23-Aug	ISOL	SCT	DRY	ISOL	ws	EWS	SCT	EWS	WS
24-Aug	SCT	SCT	ISOL	ISOL	WS	SCT	SCT	SCT	SCT
25-Aug	SCT	ISOL	ISOL	SCT	ws	SCT	SCT	ISOL	SCT
26-Aug	SCT	ISOL	ISOL	ISOL	ws	SCT	SCT	ISOL	ws
27-Aug	FWS	WS	ISOL	ISOL	WS	FWS	FWS	SCT	FWS
28-Aug	FWS	ISOL	SCT	FWS	WS	WS	WS	WS	WS
29-Aug	SCT	ISOL	ISOL	ISOL	WS	WS	FWS	WS	WS
30-Aug	ISOL	ISOL	ISOL	ISOL	WS	FWS	FWS	SCT	WS
31-Aug	SCT	ISOL	SCT	SCT	WS	WS	WS	SCT	FWS
1-Sep	SCT	ISOL	ISOL	FWS	WS	SCT	SCT	SCT	DRY
2-Sep	SCT	ISOL	ISOL	ISOL	FWS	SCT	ISOL	ISOL	DRY
3-Sep	ISOL	ISOL	ISOL	ISOL	FWS	ISOL	SCT	DRY	SCT
4-Sep	ISOL	ISOL	ISOL	ISOL	SCT	ISOL	ISOL	DRY	DRY
5-Sep	ISOL	ISOL	ISOL	ISOL	FWS	SCT	ISOL	ISOL	DRY
6-Sep	ISOL	ISOL	ISOL	ISOL	FWS	ISOL	ISOL	DRY	DRY
7-Sep	ISOL	ISOL	ISOL	ISOL	EWS	ISOL	ISOL	ISOL	DBY
-Sep	ISOL	DRV	DRY	ISOL	EWS	ISOL	ISOL	ISOL	EWS
10-Sep	ISOL	DRY	ISOL	ISOL	ISOL	ISOL	ISOL	ISOL	DRY
11-Sep	SCT	ISOL	ISOL	SCT	DRY	DRY	SCT	DRY	DRY
12-Sep	SCT	SCT	FWS	ISOL	DRY	ISOL	FWS	ISOL	DRY
13-Sep	ISOL	ISOL	ISOL	ISOL	DRY	DRY	ISOL	DRY	DRY
14-Sep	SCT	ISOL	ISOL	SCT	DRY	DRY	ISOL	DRY	DRY
15-Sep	SCT	ISOL	ISOL	SCT	DRY	DRY	SCT	DRY	DRY
16-Sep	ISOL	ISOL	SCT	SCT	DRY	DRY	ISOL	ISOL	SCT
17-Sep	FWS	ISOL	WS	FWS	SCT	SCT	SCT	ISOL	SCT
18-Sep	FWS	FWS	FWS	ISOL	SCT	FWS	SCT	ISOL	SCT
19-Sep	SCT	SCT	FWS	ISOL	ISOL	ISOL	ISOL	SCT	WS
20-Sep	SCT	SCT	ISOL	ISOL	ISOL	FWS	ISOL	SCT	WS
21-Sep	FWS	FWS	ISOL	ISOL	FWS	SCT	SCT	SCT	SCT
22-Sep	FWS	WS	SCT	ISOL	ISOL	SCT	ISOL	ISOL	DRY
23-Sep	ISOL	ISOL	ISOL	ISOL	ISOL	ISOL	ISOL	ISOL	FWS
24-Sep	ISOL	ISOL	ISOL	SCT	DRY	DRY	FWS	WS	DRY
25-Sep	ISOL	ISOL	ISOL	ISOL	DRY	ISOL	SCI	FWS	SCI
20-Sep	SCT	ISOL	SCT	SCT	FVVS	FVVS	FVVS	ISOL	SCT
27-Sep	ISOL	ISOL	ISOL	SCT	WS	SCT	EVVS	SCT	
29-Sep	ISOL	ISOL	ISOL	SCT	W/S	WS	W/S	WS	WS
30-Sep	ISOL	ISOL	ISOL	SCT	WS	WS	WS	EWS	SCT

				Fre	equency	(%)			
Category	CAP	TEL	RYS	TN	CK	NIK	SIK	KER	LAK
WD	5	19	2	0	77	16	22	60	37
FWD	24	13	7	4	8	30	33	10	22
SCT	31	20	19	19	4	33	33	11	21
ISOL	39	44	65	76	4	16	12	13	0
DRY	1	4	7	1	7	6	0	6	20

Table-4b:Percentage frequency of various categories of daily spatial rainfall distributionover the subdivisions of the SP region during SWM season, 2018

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



Fig.4 Daily cumulative rainfall over southern peninsular region during SWM season, 2018

Table-5 presents the monthly and seasonal frequency of active and vigorous monsoon days over the various sub divisions of the SP region during the SWM season, 2018. SIK & KER experienced more than 30 days (34 and 32 days respectively) of *active* to *vigorous* monsoon activity during the season. 18-21 days of *active* to *vigorous* monsoon conditions prevailed over CAP, TEL & CK. NIK experienced 13 days *active* to *vigorous* monsoon conditions. There were only 7 days, 3 days and 1 day of *active* to *vigorous* monsoon conditions over RYS, TN & LAK respectively during the season. The highest number of *active* to *vigorous* monsoon days was experienced by KER in June and July, (10 days and 11 days respectively) and by SIK in August

and September (12 days & 6 days respectively). Also, there were 4 days of vigorous monsoon and 6 days of active monsoon conditions over Kerala in August.

Subdivision	JU	IN	JL	JUL		AUG		SEP		Jun-Sep	
	VIG	ACT									
COASTAL ANDHRA PRADESH	1	0	0	10	2	3	0	2	3	15	
TELANGANA	2	4	0	8	3	3	0	1	5	16	
RAYALASEEMA	0	0	0	1	0	3	1	2	1	6	
TAMIL NADU & PUDUCHERRY	0	0	1	0	1	0	0	1	2	1	
COASTAL KARNATAKA	1	7	0	3	1	8	0	0	2	18	
NORTH INTERIOR KARNATAKA	1	2	0	3	0	3	0	4	1	12	
SOUTH INTERIOR KARNATAKA	4	2	0	10	1	11	0	6	5	29	
KERALA	0	10	1	10	4	6	0	1	5	27	
LAKSHADWEEP	0	0	0	0	0	1	0	0	0	1	

## Table-5: Subdivision-wise frequency of Vigorous and Active monsoon conditions over theSP region during SWM season, 2018

**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).

**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)

#### 2.5 District-wise seasonal rainfall distribution

Table -6 presents the district rainfall distribution as percentage departures from normal over the nine meteorological sub divisions of the SP region during the period Jun-Sep 2018 and Fig.5, the district-wise seasonal rainfall over the various states and UTs over the SP region. Of the 123 districts in the SP region [Andhra Pradesh: 13 (CAP-9 & RYS-4), Telangana: 31, Tamil Nadu and Puducherry: 34 (34 and 2 respectively), Karnataka: 30 (CK-3, NIK-11 & SIK-16), Kerala and Lakshadweep: 15 (14 and 1 respectively)], 72 districts received *normal to excess & large excess* rainfall during the season. The remaining 51 districts came under the *deficient* category. Idukki district in Kerala which normally receives 227 cm of rainfall during the season recorded *large excess* (+67%) rainfall of 379 cm during Jun-Sep 2018. Coimbatore, Theni & Tirunelveli

districts in Tamil Nadu which normally receive 14-19 cm of rainfall during the season also recorded *large excess* rainfall of +244%, +199% and +142% respectively. Whereas all the districts in Kerala and CK (14 & 3 respectively) received normal to excess/large excess rainfall, all the four districts in Rayalaseema and the lone district of Lakshadweep ended up *deficient* at the end of the season. In NIK, 10 out of 11 districts came under deficient category. In CAP, but for the two southern districts of Nellore and Prakasam which came under deficient category, all other districts received normal to excess rainfall. In Telangana, by and large, the eastern districts recorded rainfall on the positive side of the normal (*normal* to *excess*) and the western districts, on the negative side of the normal (deficient to normal) with the eastern districts of Khamman, Badradri Kothagudem, Jayashankar Bhupalpally and Peddapalle and Adilabad in the extreme north receiving excess rainfall. In Karnataka (CK, NIK & SIK), but for the coastal and the adjoining districts and those along the western ghat section which received, by and large, normal to excess rainfall (Kodagu, Mysuru, Hassan (SIK) & Belagavi (NIK) under excess category), most of the interior districts received only *deficient* rainfall with Yadgir falling under *large* deficient category (-65%). In Tamil Nadu & Puducherry also, the districts along the western ghats & the adjoining districts were the main beneficiaries from the monsoon with normal to excess rainfall. The rest of TN & PDC, but for 4 northeastern coastal districts, ended up deficient.

	Total No. of	No. (	of districts mons	under vari soon perfo	ous categor rmance	ies of
Met. Sub division	districts	Large Excess	Excess	Normal	Deficient	Large Deficient
COASTAL ANDHRA PRADESH	9	0	2	5	2	0
RAYALASEEMA	4	0	0	0	4	0
TELANGANA	31	0	5	17	9	0
TAMIL NADU & PUDUCHERRY	34	3	3	9	19	0
COASTAL KARNATAKA	3	0	0	3	0	0
NORTH INTERIOR KARNATAKA	11	0	1	0	10	0
SOUTH INTERIOR KARNATAKA	16	0	3	7	6	0
KERALA	14	1	6	7	0	0
LAKSHADWEEP	1	0	0	0	1	0

Table-6:	District	: rainfall	performance	over	various	sub	divisions	of	the	SP	region	during
June-Sep	otember,	2018										





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



Fig.5 (contd.)

### 2.6 Heavy rainfall activity and extreme rainfall events

Table-7a presents the number of days of *heavy* rainfall occurrences ( $\geq$  7 cm/day) over the various subdivisions of the SP region during SWM 2018 and the month-wise frequencies are presented in Table 7b. In the seasonal scale, CK and SIK recorded 72 and 71 days of heavy rainfall events respectively which included 35 and 37 days respectively of isolated *very heavy* rainfall occurrences with 10 days each of *extremely heavy* rainfall events. Kerala reported 59 days of *heavy* rainfall occurrences with 28 days of *isolated very heavy* rainfall and 6 days of *isolated extremely heavy* rainfall during the season. TN&PDC, TEL and CAP recorded 25-40 days of *heavy* rainfall events and NIL, RYS and LAK reported only 17, 10 and 3 days respectively of *heavy* rainfall occurrence. List of *very heavy* to *extremely heavy* rainfall events is presented in Table 7c.

	No. of day (Rain	ys of Heavy rai fall ≥ 7 cm/day)	nfall )
Subdivision	Extremely Heavy (≥21 cm/day)	Very Heavy (≥12 cm/day)	<i>Heavy</i> (≥7 cm/day)
COASTAL ANDHRA PRADESH	1	8	27
TELANGANA	3	9	34
RAYALASEEMA	0	3	10
TAMIL NADU & PUDUCHERRY	1	11	38
COASTAL KARNATAKA	10	35	72
NORTH INTERIOR KARNATAKA	0	1	17
SOUTH INTERIOR KARNATAKA	10	37	71
KERALA	6	28	59
LAKSHADWEEP	0	0	3

Table-7a:Subdivision-wise frequency of heavy rainfall days over the SP region during1<sup>st</sup>June-30<sup>th</sup>Sep 2018

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

Sub-division			No.	of days	of Hea	vy raiı	nfall (F	Rainfall	$\geq$ 7 cm	/day)		
		June			July			Aug			Sep	
	ExH	VH	H	ExH	VH	H	ExH	VH	H	ExH	VH	H
COASTAL ANDHRA PRADESH	0	1	6	0	3	8	1	4	9	0	0	4
TELANGANA	0	2	12	0	0	8	3	6	8	0	1	6
RAYALASEEMA	0	2	4	0	0	1	0	0	1	0	1	4
TAMIL NADU & PUDUCHERRY	0	3	7	0	4	6	1	2	11	0	2	14
COASTAL KARNATAKA	4	16	22	2	11	24	4	8	25	0	0	1
NORTH INTERIOR KARNATAKA	0	1	6	0	0	6	0	0	2	0	0	3
SOUTH INTERIOR KARNATAKA	5	16	24	1	12	20	4	9	21	0	0	6
KERALA	2	11	20	1	9	22	3	7	13	0	1	4
LAKSHADWEEP	0	0	1	0	0	1	0	0	0	0	0	1

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

*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 occurrences with rainfall amount during Jun-Sep 2018

District	Date, Station and 24-hr accumulated rainfall (in cm)
	COASTAL ANDHRA PRADESH
East Godavari	Jun <sup>:</sup> 28 <sup>th</sup> . Amalanuram -13 <sup>·</sup>
Lust Godavan	<b>Jul:</b> $3^{rd}$ : Amalapuram – 17:
	Aug: $11^{\text{th}}$ : Vararamachandrapur – 13. Chintur – 12: $13^{\text{th}}$ : Peddapuram – 12:
	20 <sup>th</sup> : Vararamachandrapur - 16, Kunavaram, Chintur – 15 each.
West Godavari	<b>Jul</b> : 15 <sup>th</sup> : Kukunoor – 12;
	Aug: $11^{\text{th}}$ : Koida – 12; 20 <sup>th</sup> : Koida -39, Kukunoor - 29, Velairpad - 28,
	Koyyalagudem, Bhimadole – 13 each.
Srikakulam	Jul: 21 <sup>st</sup> : Palasa - 15, Sompeta, Mandasa – 12 each;
	Aug: 15 <sup>th</sup> : Palakonda – 13.
Krishna	Aug: 20 <sup>III</sup> : Tiruvuru (dist Krishna) - <mark>19</mark> .
	TELANGANA
Mancherial	<b>Jun:</b> $08^{\text{th}}$ : Chennur – 13;
771	Aug: 12 <sup>th</sup> : Luxettipet – 27, Mancherial - 19, Chennur – 13.
Khammam	Aug: 11 <sup>th</sup> : Khammam Urban, Chinthakam, Kusumanchi – 13 each;
D V oth o and and	20 : Enkuru, Satnupalle – 13 each.
D.Komagudem	Aug: 11 : Diladiacharani $-12$ , 12 : Piliapaka - 10, Guildara - 15; $20^{\text{th}}$ . Aswaraopata Aswaraopat(a) 21 asah Bhadrashalam 15
	$20^{\circ}$ . Aswaraopeta, Aswaraopet(a) – $21^{\circ}$ cach, Bhadracharann - $13^{\circ}$ , Mulakalanalle - $14^{\circ}$ Burgampadu, Dummugudem – $12^{\circ}$ each
Peddanalle	Aug: $12^{\text{th}}$ : Ramoundam - 27 Julanalle - 20 Manthani - 19 Sultanabad - 18
Adilabad	Aug: $12^{\text{th}}$ : Utnur - 25 Adilabad - 15: $17^{\text{th}}$ : Boath - 19:
1 Killioud	Sep: $22^{nd}$ : Utnur – 13.
J.Bhupalpally	Aug: 12 <sup>th</sup> : Venkatapuram - 25, Venkatapur - 23, Mulug - 19, Govindaraopet - 17,
	Bhupalpalle - 15, Mogullapalle - 14, Kaleswaram – 12; 16 <sup>th</sup> : Perur – 19;
	$20^{\text{th}}$ : Venkatapuram – $12$ .
Jagtial	Aug: 12 <sup>th</sup> : Dharmapuri - 21, Pegadapalle - 14, Jagtial, Mallial – 12 each.
Warangal-rural	Aug: 12 <sup>th</sup> : Shayampet - 14, Parkal, Nallabelly – 13 each.
Nirmal	Aug: 12 <sup>th</sup> : Khanpur – 14.
Karimnagar	Aug: 12 <sup>th</sup> : Karimnagar - 14, Gangadhara, Thimmapur, Huzurabad – 12 each.
Nizamabad	<b>Aug</b> : 12 <sup>th</sup> : Navipet -12; 21 <sup>st</sup> : Navipet - 21, Bodhan -19, Varni - 17, Ranjal,
	Nandipet – $16$ each, Yeda Palle - $15$ , Armur, Velpur – $14$ each, Kotgiri - $13$ ,
IZ DI	Nizamabad $-\frac{12}{12}$ .
Kumaram Bheem	Aug: $16^{\text{m}}$ : Sirpur (t) -17, Asifabad – 13.
Suryapet	Aug: $20$ : Survapet – 12.
Anontonur	<b>KATALASEENIA</b>
Anantapui	Sen: $17^{\text{th}}$ : Anantpur $_{-17}^{17}$ , $4$ : Anantpur $_{-17}^{17}$ , $4$ : Anantpur $_{-17}^{17}$ , $17$
	TAMIL NADIL & PUDUCHERRY
Arivalur	Jun: 4th: Arivalur - 13.
Coimbatore	<b>Jun</b> : 10 <sup>th</sup> : Chinnakalar - 19. Valparai PTO - 17. Valparai taluk office – 15:
	11 <sup>th</sup> : Chinnakalar - 14, Valparai PTO - 12; 12 <sup>th</sup> : Chinnakalar, Valparai PTO – 13
	each; 14 <sup>th</sup> : Chinnakalar – 12;
	Jul: 11 <sup>th</sup> : Chinnakalar - 17, Valparai PTO - 15, Valparai taluk office - 13;
	16 <sup>th</sup> : Chinnakalar - 19, Valparai PTO – 12; 17 <sup>th</sup> : Chinnakalar – 16;
	Aug: 8 <sup>th</sup> : Chinnakalar – 12; 9 <sup>th</sup> : Valparai PTO – 17, Chinnakalar - 12;

	1 - 4h
	14 <sup>th</sup> : Valparai PTO - <mark>18</mark> , Chinnakalar - <mark>17</mark> ;
	15 <sup>th</sup> : Chinnakalar - 21, Valparai PTO - 16, Valparai taluk office – 14;
	<b>16<sup>th</sup>:</b> Valparai PTO - <mark>31</mark> , Valparai taluk office – <b>19</b> ; <b>17<sup>th</sup>:</b> Chinnakalar - <mark>26</mark> ,
	Valparai PTO - 21, Valparai taluk office – 17.
Tirunelveli	<b>Jun</b> : 10 <sup>m</sup> : Papanasam - 12; 11 <sup>m</sup> : Papanasam -12;
	Aug: 15 <sup>th</sup> : Shencottah - 27, Papanasam – 19.
Theni	Jun: 11m: Periyar - 12;
	Aug: 15 <sup>th</sup> : Periyar - 13; 16 <sup>th</sup> : Periyar – 12.
Pudukkottai	Jul: 1 <sup>st</sup> : Alangudi – 12.
Salem	$\frac{\text{Jul}}{\text{Jul}}: 2^{\text{nd}}: \text{Salem} - \frac{13}{\text{N}}, \text{Yercaud} - \frac{12}{\text{N}}.$
Tiruchirapalli	Jul: 3 <sup>rd</sup> : Samayapuram – 17.
Kanyakumari	Jul: 31st: Thucklay - 15;
	Aug: 15 <sup>th</sup> : Pechiparai – 20.
Nilgiris	Aug: 15 <sup>th</sup> : Devala – 13; 16 <sup>th</sup> : Devala – 17, Naduvattam - 12.
Virudhunagar	<mark>Sep</mark> : 16 <sup>th</sup> : Sivakasi – <mark>13</mark> .
Dindigul	<mark>Sep</mark> : 17 <sup>th</sup> : Nilakottai – <mark>13</mark> .
	COASTAL KARNATAKA
Dakshin Kannada	Jun: 8 <sup>th</sup> : Mangaluru AP – 16, Mulki, Mani - 14 each, Panambur, Puttur - 13 each,
	Mudubidre, Sulya – $12$ each; $10^{\text{th}}$ : Mulki - $12$ ; $14^{\text{th}}$ : Mani – $20$ , Sulya – $19$ ,
	Puttur - 18, Dharmasthala – 17, Mudubidre - 16; 20 <sup>th</sup> : Mangaluru – 15,
	Mangaluru AP - 12; 21 <sup>st</sup> : Mulki - 22, Mudubidre, Panambur - 12 each;
	$26^{\text{th}}$ : Mulki - $13$ ; $28^{\text{th}}$ : Mudubidre – $20$ , Bantwal, Sulya - $16$ each,
	Subrahmanya – 15, Belthangadi, Dharmasthala, Mani – 13 each, Puttur - 12;
	<b>Jul</b> : 8 <sup>th</sup> : Mulki - 28, Mani – 20, Mangaluru AP – 16, Mudubidre, Sulya,
	Puttur - $13$ each; $19^{\text{ut}}$ : Mangaluru - $12$ ; $20^{\text{ut}}$ : Belthangadi - $15$ ;
	24 <sup>th</sup> : Subrahmanya – $15$ ;
	Aug: $9^{\text{aug}}$ : Dharmasthala – 15, Belthangadi - 13; 13 <sup><math>\text{aug}</math></sup> : Mudubidre – 13,
	Subrahmanya – 12; 14 <sup>th</sup> : Subrahmanya - 16, Mudubidre - 13;
	15 <sup>th</sup> : Mudubidre – 13, Subramanya, Dharmasthala - 12 each;
	<b>16</b> <sup>th</sup> : Subrahmanya - <b>24</b> , Belthangadi - <b>16</b> , Dharmasthala - <b>13</b> ;
**1 *	$17^{-1}$ : Subrahmanya – 12.
Udupi	<b>Jun</b> : $8^{-1}$ : Siddapura – 21, Kollur – 18, Karkala, Kundapur, Kota - 16 each,
	Udupi = 15; 10: Kota - 12; 12: Kollur = 20; 13: Kollur = 22; 15 <sup>th</sup> , Kollur Siddenurg = 14 coch = 26 <sup>th</sup> , Kota = 15, 28 <sup>th</sup> , Kollur = 26 <sup>th</sup>
	<b>15</b> : Kollur, Siddapura - <b>14</b> each; <b>20</b> : Kola - <b>15</b> ; <b>26</b> : Kollur - <b>20</b> ; <b>14</b> : $14^{\text{th}}$ , Kollur - <b>10</b> ; $21^{\text{st}}$ , Siddapur - <b>10</b> ;
	<b>Jul:</b> 14 : Kollur - 12; 21 : Sludapur - 12; Aug. $11^{th}$ , Kollur - 16; $12^{th}$ , Kollur - 20; $13^{th}$ , Kollur - 25; Siddenur - 12;
	Aug. 11 . Kollur - 10, 12 . Kollur - 20, 15 . Kollur - 23, Sludapula - 12, $14^{\text{th}}$ . Kollur - 20 Siddepure - 26 Kote - 24 Kundepur - 22 Liduni - 15.
	14 . Kollur $-50$ , Sludapura $-20$ , Kola $-24$ , Kuluapur $-22$ , Odupr $-13$ , $15^{\text{th}}$ . Kollur $-20$ Kota Karkala $-12$ each
Uttara Kannada	$\frac{10}{100} \cdot \frac{10}{100} \cdot \frac{10}{100} \cdot \frac{15}{100} \cdot \frac{15}{100} \cdot \frac{12}{100} \cdot \frac{11}{100} \cdot 1$
	$10^{\text{th}}$ . Karwar $= 14$ Kadra $= 13^{\circ}$ . $11^{\text{th}}$ . Castle Rock $= 15$ Jagalbet $= 13^{\circ}$ .
	$13^{\text{th}}$ : Gersonna - 15: 15 <sup>th</sup> : Gersonna - 13: 27 <sup>th</sup> : Gersonna - 12:
	$28^{\text{th}}$ : Gersoppa - 13, 13 : Gersoppa - 13, 27 : Gersoppa - 12, 28^{\text{th}}: Gersoppa - 21: 29 <sup>th</sup> : Castle Rock - 13 Shirali - 12:
	<b>Jul:</b> $3^{rd}$ : Karwar - 12: $6^{th}$ : Kadra - 18. Castle Rock - 15: $8^{th}$ . Castle Rock - 13.
	$10^{\text{th}}$ : Gersoppa – 16. Castle Rock - 14: $11^{\text{th}}$ : Castle Rock - 14:
	$12^{\text{th}}$ : Castle Rock - 12:
	Aug: 12 <sup>th</sup> : Castle Rock - 12; 13 <sup>th</sup> : Castle Rock - 20; Gersoppa – 12:
	$16^{\text{th}}$ : Castle Rock - $17$ ; $17^{\text{th}}$ : Castle Rock - $22$ .
	NORTH INTERIOR KARNATAKA
Kalaburgi	Jun: 8 <sup>th</sup> : Khajuri – <mark>14</mark> .

	SOUTH INTERIOR KARNATAKA
Shivamogga	<b>Jun</b> : $8^{\text{th}}$ : Agumbe - $\frac{17}{17}$ ; $9^{\text{th}}$ : Agumbe - $\frac{12}{12}$ ; $11^{\text{th}}$ : Agumbe - $\frac{14}{14}$ ;
	$12^{\text{th}}$ : Talaguppa - 18; 13 <sup>th</sup> : Linganamakki - 17; 14 <sup>th</sup> : Agumbe - 19;
	28 <sup>th</sup> : Agumbe - 30;
	<b>Jul</b> : $8^{\text{th}}$ : Agumbe - 14; 10 <sup>th</sup> : Agumbe - 13; 11 <sup>th</sup> : Agumbe - 15, Talaguppa - 12;
	$12^{\text{th}}$ : Agumbe - 16; 13 <sup>th</sup> : Agumbe - 16; 14 <sup>th</sup> : Agumbe - 15; 17 <sup>th</sup> : Agumbe - 13;
	<b>18<sup>th</sup></b> : Agumbe $-$ <b>20</b> ; <b>21<sup>st</sup></b> : Agumbe $-$ <b>16</b> ;
	Aug: $9^{\text{m}}$ : Agumbe – 13; 12 <sup>m</sup> : Agumbe – 13; 13 <sup>m</sup> : Agumbe - 12;
	14 <sup>th</sup> : Agumbe - 30, Linganamakki – 20, Humchadakatte – 18;
	$15^{\text{th}}$ : Agumbe – 23; 16 <sup>th</sup> : Agumbe – 20; 17 <sup>th</sup> : Agumbe – 13; 19 <sup>th</sup> : Agumbe – 13.
Chikkamagaluru	<b>Jun</b> : 8 <sup>th</sup> : Kottigehara - 16; 10 <sup>th</sup> : Kottigehara - 12; 11 <sup>th</sup> : Kottigehara - 13;
	$12^{\text{m}}$ : Kalasa, Koppa – $13$ each, Kammaradi - $12$ ; $13^{\text{m}}$ : Kammaradi – $22$ ,
	Kottigehara – 18, Koppa - 16, Sringeri - 15; 14 <sup>th</sup> : Sringeri - 12;
	28 <sup>th</sup> : Kammaradi – 18, Koppa - 13, Sringeri, Kalasa - 12 each;
	<b>Jul</b> : $9^{-1}$ : Sargur, Sringeri - 13 each; $10^{-1}$ : Sringeri - 14;
	11 : Sringeri, Kammaradi, Koppa - 13 each; 12 : Sringeri – 15, Kammaradi, 14 Kattiashara, 12
	Kallillaradi - 14, Kottigellara - 12, Aug: 13 <sup>th</sup> : Vermeredi - 12, Kottigehere, Konne - 12 each:
	Aug. 15 . Kallinaradi - 15, Kolligenara, Koppa - 12 each, $14^{\text{th}}$ : Kammaradi - 20 Kattigahara - 10 Kappa - 18 Kalasa - 17 Jayanura - 16
	14 . Kalinfaldu – 20, Kolugenara – 19, Koppa – 18, Kalasa – 17, Jayapura – 10, Sringeri – 15, Talaguppa – 14
Kodagu	$\frac{1}{100} \cdot \frac{8^{\text{th}}}{8} = \frac{10}{100} \cdot \frac{10}{100} \cdot$
Kouagu	$11^{\text{th}}$ . Bhagamandala - $17^{\circ}$ , $12^{\text{th}}$ . Napoklu - $13^{\circ}$ , $13^{\text{th}}$ . Ponnampet - $23^{\circ}$
	Napoklu $-19$ Bhagamandala $-13$ .
	$14^{\text{th}}$ : Bhagamandala – 19. Napoklu - 13: 27 <sup>th</sup> : Bhagamandala - 17:
	28 <sup>th</sup> : Bhagamandala - 16;
	<b>Jul</b> : $8^{\text{th}}$ : Bhagamandala – 14; $9^{\text{th}}$ : Madikeri - 14; $10^{\text{th}}$ : Madikeri - 12;
	11 <sup>th</sup> : Bhagamandala - 17; 13 <sup>th</sup> : Bhagamandala - 15; 14 <sup>th</sup> : Bhagamandala - 15;
	<b>16<sup>th</sup>:</b> Madikeri - <b>12</b> ; <b>17<sup>th</sup>:</b> Bhagamandala - <b>14</b> ;
	Aug: 9 <sup>th</sup> : Madikeri – 14; 13 <sup>th</sup> : Madikeri, Madapura – 13 each;
	14 <sup>th</sup> : Bhagamandala – 25, Napoklu - 17, Madapura - 13, Somawarpet - 12;
	<b>15<sup>th</sup>:</b> Bhagamandala – 23, Madikeri – 21; 16 <sup>th</sup> : Madikeri – 26, Bhagamandala,
	Madapura – $17$ each; $17^{\text{th}}$ : Bhagamandala - $21$ , Virajpet – $16$ , Ponnampet – $12$ ;
	18 <sup>th</sup> : Madikeri - 15.
Hassan	<b>Jun</b> : $11^{\text{m}}$ : Sakaleshpura - $\frac{15}{15}$ ; $12^{\text{m}}$ : Sakaleshpura - $\frac{26}{15}$ .
A 1 1	
Alappuzha	<b>Jun</b> : $3^{-1}$ : Kayamkulam Agri - 14, Kayamkulam - 13;
	Jul: 10 : Kottayam, Cherthala - 14 each, Mancompu - 13, Alappuzna,
	Chengannui – $12$ each, $51$ . Mancompu – $13$ , Changannui – $12$ ,
Kottayam	<b>Aug. 15</b> . Halipau , Kayalikulali $-12$ .
Kottayani	$\frac{13}{10} = \frac{13}{10}$
	$\frac{11}{4 n \sigma}$ $\frac{16^{\text{th}}}{16}$ Kozha - $\frac{14}{14}$
Kasargode	$\frac{1}{100} \cdot \frac{8^{\text{th}}}{100} \cdot \frac{17}{100}$
Kozhikode	<b>Jun</b> : $8^{\text{th}}$ : Vadaka – $15^{\text{c}}$ : $10^{\text{th}}$ : Vadakara – $17^{\text{c}}$ : $15^{\text{th}}$ : Vadakara – $14^{\text{c}}$
Rozinkouč	$21^{\text{st}}$ : Vadakara – 16: $28^{\text{th}}$ : Vadakara – 14:
	<b>Jul</b> : $12^{\text{th}}$ : Vadakara – 13: $18^{\text{th}}$ : Vadakara – 15. Ouilandy - 13:
	<b>19<sup>th</sup>:</b> Vadakara – <b>13</b> ;
	Aug: 15 <sup>th</sup> : Kozhikode - 20, Quilandy - 15; 16 <sup>th</sup> : Vadakara - 26, Quilandy - 16,
	Kozhikode – 13.
Kannur	<b>Jun</b> : 8 <sup>th</sup> : Irikkur – 14, Kannur – 12; 10 <sup>th</sup> : Kannur, Taliparamba – 12 each;

	$14^{\text{th}}$ : Irikkur – 16; $28^{\text{th}}$ : Kannur – 12;
	<b>Aug</b> : 15 <sup>th</sup> : Irikkur – 18, Kannur - 14, Taliparamba – 14.
Palakkad	<b>Jun</b> : 10 <sup>th</sup> : Parambikulam - 13; 13 <sup>th</sup> : Mannarkad – 18; 14 <sup>th</sup> : Ottappalam – 16,
	Parambikulam, Mannarkad - 12 each;
	Jul: 11 <sup>th</sup> : Palakkad, Mannarkad – 13 each, Ottappalam – 12;
	Aug: 9 <sup>th</sup> : Palakkad – 21, Mannarkad - 17, Chittur – 15; 14 <sup>th</sup> : Ottapalam – 13;
	$15^{\text{th}}$ : Alathur - $18$ , Parambikulam – $15$ , Pattambi – $12$ ;
	<b>16<sup>th</sup>: Mannarkad - 24</b> , Alathur - 23, Ottappalam, Thrithala - 21 each,
	Pattambi - 18, Palakkad, Kollengode – 17 each, Parambikulam – 15;
	$17^{\text{th}}$ : Alathur – 12.
Idukki	<b>Jun</b> : 10 <sup>th</sup> : Peermade - 12; 11 <sup>th</sup> : Peermade – 32, Munnar – 13;
	<b>Jul</b> : $11^{\text{th}}$ : Peermade – $12$ ; $16^{\text{th}}$ : Munnar - $20$ , Peermade – $19$ , Idukki,
	Thodupuzha - 15 each;
	<b>Aug</b> : $8^{\text{th}}$ : Idukki - 13, Peermade – 12; $9^{\text{th}}$ : Munnar, Peermade - 25 each,
	Myladumpara – $\frac{21}{10}$ ; $10^{\text{th}}$ : Peermade – $\frac{16}{16}$ , Idukki – $\frac{13}{13}$ ; $14^{\text{th}}$ : Munnar - $\frac{12}{12}$ ;
	$15^{\text{th}}$ : Peermade - $27$ , Idukki - $23$ , Munnar – $22$ , Thodupuzha – $17$ ,
	Myladumpara – 14;
	$16^{\text{th}}$ : Peermade – $\frac{35}{5}$ , Thodupuzha – $\frac{18}{17}$ ; $17^{\text{th}}$ : Peermade - $\frac{19}{5}$ , Munnar – $\frac{13}{15}$ .
Wayanad	<b>Jun</b> : 11 <sup>th</sup> : Vythiri – 15; 13 <sup>th</sup> : Vythiri - 15; 14 <sup>th</sup> : Vythiri - 15;
	<b>Jul</b> : $10^{\text{th}}$ : Vythiri - $\frac{17}{17}$ ; $11^{\text{th}}$ : Vythiri - $\frac{15}{15}$ ; $12^{\text{th}}$ : Mananthavady - $\frac{12}{12}$ ;
	<b>Aug</b> : 8 <sup>th</sup> : Vythiri – 14, Mananthavady – 12; 9 <sup>th</sup> : Mananthavady – 31,
	Ambalavayal – 12; 15 <sup>th</sup> : Mananthavady - 16, Vythiri – 15, Kuppady - 12.
Malappuram	<b>Jun</b> : $13^{\text{th}}$ : Nilambur – $17$ ; $14^{\text{th}}$ : Manjeri – $23$ , Nilambur - $21$ , Karipur AP – $20$ ,
	Perinthalmanna - 12;
	Aug: 8 <sup>th</sup> : Nilambur – <mark>15</mark> ; 9 <sup>th</sup> : Nilambur – <mark>40</mark> ;
	15 <sup>th</sup> : Karipur AP – 21, Manjeri - 20, Perinthalmanna - 15, Angadippuram - 14,
	Nilambur - <mark>13</mark> , Ponnani – <mark>12</mark> ;
	<b>16<sup>th</sup>:</b> Ponnani - <mark>27</mark> , Manjeri - <mark>17</mark> , Perinthalmanna, Angadippuram – <mark>16</mark> each,
	Nilambur - <mark>15</mark> , Karipur AP – <mark>13</mark> .
Thrissur	<b>Jun</b> : 14 <sup>th</sup> : Vellanikkara, Vadakkancherry - 13 each;
	Aug: 15 <sup>th</sup> : Vadakkancherry - 15, Vellanikkara, Kodungallur - 14 each,
	Irinjalakuda – <mark>12</mark> ;
	<b>16<sup>th</sup>:</b> Vellanikkara & Enamackel - 25 each, Kunnamkulam – 23, Chalakudy - 22,
	Irinjalakuda - 19, Kodungallur – 18; 17 <sup>th</sup> : Vellanikkara, Irinjalakuda - 15 each.
Ernakulam	Jun: 21 <sup>st</sup> : Piravom – 12;
	<b>Jul</b> : $10^{\text{th}}$ : Piravom – $15$ ; $11^{\text{th}}$ : Piravom - $16$ ; $16^{\text{th}}$ : Kochi AP – $23$ , Piravom – $22$ ,
	C.I.A.L. Kochi – 16, Aluva – 15; $31^{st}$ : Piravom – 17;
	Aug: $15^{\text{th}}$ : C.I.A.L. Kochi – 17, Perumbavur – 16, Piravom - 15, Aluva – 14;
	$16^{\text{cm}}$ : Ernakulam South - 14, Piravom – 13.
Pathanamthitta	Jul: 16 <sup>th</sup> : Kurudamannil – 12;
	Aug: 16 <sup>th</sup> : Konni - 12.
Kollam	Aug: 15 <sup>th</sup> : Aryankavu – 18.
Thiruvananthapuram	Aug: 15 <sup>th</sup> : Thiruvananthapuram City - 14, Thiruvananthapuram AP – 13.

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

It is noted that maximum number of days of *very heavy* - *extremely heavy* rainfall occurred in CK (33days) followed by SIK (29 days) and Kerala (24 days).

In CK, the 33 days of *very heavy / extremely heavy* rainfall activity occurred on 8<sup>th</sup>-15<sup>th</sup>, 20<sup>th</sup>-21<sup>st</sup>, 26<sup>th</sup>-29<sup>th</sup> June, 3<sup>rd</sup>, 6<sup>th</sup>, 8<sup>th</sup>, 10<sup>th</sup>-12<sup>th</sup>, 14<sup>th</sup>, 19<sup>th</sup>- 21<sup>st</sup> & 24<sup>th</sup> July and 9<sup>th</sup>, 11<sup>th</sup>-17<sup>th</sup> August. *Extremely heavy* rain occurred at isolated places in Dakshin Kannada / Udupi / Uttara Kannada districts on 8<sup>th</sup>, 13<sup>th</sup>, 21<sup>st</sup> & 28<sup>th</sup> June, 8<sup>th</sup> July and 13<sup>th</sup>-14<sup>th</sup> and 16<sup>th</sup>-17<sup>th</sup> August with highest rainfall of 30 cm/day at Kollur in Udupi district on 14<sup>th</sup> August.

In SIK, 29 days (8<sup>th</sup>-14<sup>th</sup>, 27<sup>th</sup>-28<sup>th</sup> June, 8<sup>th</sup>-14<sup>th</sup>, 16<sup>th</sup>-18<sup>th</sup> & 21<sup>st</sup> July and 9<sup>th</sup>, 12<sup>th</sup>-19<sup>th</sup> August) of isolated *very heavy / extremely heavy* rainfall occurred mainly in the western ghat areas of Shivamogga, Chikkamagaluru, Kodagu and Hassan districts during the season. There were recurrent *very heavy / extremely heavy* rainfall events at Agumbe (Shivamogga district), Kammaradi, Sringeri (both Chikkamagaluru district) and Bhagamandala, Madikeri (both Kodagu district) with *extremely heavy* rain on 3 days in Agumbe (28<sup>th</sup> June, 14<sup>th</sup> & 15<sup>th</sup> Aug) and Bhagamandala (14<sup>th</sup>, 15<sup>th</sup> & 17<sup>th</sup> Aug), 2 days in Madikeri (15<sup>th</sup> & 16<sup>th</sup> Aug) and one day in Kammaradi (13<sup>th</sup> June). *Extremely heavy* rain was also reported from Sakaleshpura (Hassan district) on 12<sup>th</sup> June and Ponnampet (Kodagu district) on 13<sup>th</sup> June. Highest rainfall of 30 cm/day was reported from Agumbe on 28<sup>th</sup> June and 14<sup>th</sup> August.

In Kerala, very heavy / extremely heavy rainfall occurred on 24 days (3<sup>rd</sup>-4<sup>th</sup>, 8<sup>th</sup>, 10<sup>th</sup>-11<sup>th</sup>, 13<sup>th</sup>-15<sup>th</sup>, 21<sup>st</sup> & 28<sup>th</sup> June, 10<sup>th</sup>-12<sup>th</sup>, 16<sup>th</sup>, 18<sup>th</sup>-19<sup>th</sup> & 31<sup>st</sup> July and 8<sup>th</sup>-10<sup>th</sup>, 14<sup>th</sup>-17<sup>th</sup> August) during the season. All the 14 districts experienced *very heavy / extremely heavy rain* at least on one day during the period 14<sup>th</sup>-17<sup>th</sup> August. There were recurrent *very heavy / extremely heavy rain* at least on one day during the western ghat areas - Peermade, Munnar, Thodupuzha, Idukki (all in Idukki district), Nilambur (Malappuram district), Palakkad, Mannarkad, Parambikulam and Ottapalam (all in Palakkad district). Highest rainfall of 40 cm/day was recorded on 9<sup>th</sup> August in Nilambur in Malappuram district followed by 35 cm/day on 16<sup>th</sup> August in Peermade in Idukki district in Kerala.

On 15<sup>th</sup> August, almost all the stations in Kerala that reported rainfall (65/68) recorded *heavy* rainfall occurrence with about 50% of the stations reporting *very heavy* (32 stations) to *extremely heavy* rainfall (4 stations) during the 24-hr ending 0830 IST of the day. During the 10-day period from 8<sup>th</sup> to 17<sup>th</sup> August, there were 7 days of *very heavy* to *extremely heavy* rainfall occurrence. However, after 20<sup>th</sup> August, there was no heavy rainfall occurrence over Kerala for over a month and isolated *heavy* rain occurred only during the last week of September.

Associated with recurrent heavy rainfall activity during June-August, water inflow into most of the water storage reservoirs and dams over Kerala increased substantially leading to filling up of the dams up to the limit of maximum storage capacity and unprecedented flooding over Kerala during the  $2^{nd}$  - $3^{rd}$  weeks of August. Though rainfall was the main factor for the flood, local terrain, dam water management, drainage system infrastructure, all played a vital role in the devastation caused. Some important features associated with the heavy rainfall and flooding over Kerala during the  $2^{nd}$  - $3^{rd}$  weeks of August are discussed separately in Section 3.

In TN, there were 20 days of isolated *very heavy / extremely heavy* rainfall activity (4<sup>th</sup>, 10<sup>th</sup>-12<sup>th</sup> & 14<sup>th</sup> June, 1<sup>st</sup>- 3<sup>rd</sup>, 11<sup>th</sup>, 16<sup>th</sup>- 17<sup>th</sup> & 31<sup>st</sup> July, 8<sup>th</sup>- 9<sup>th</sup> and 14<sup>th</sup>-17<sup>th</sup> August & 16<sup>th</sup>-17<sup>th</sup> September). However, such *very heavy / extremely heavy* rainfall activity was mainly confined to stations located in the western ghat areas of Coimbatore district (Valparai & Chinnakalar on 13 days during the season). Hilly areas of Theni and Tirunelveli districts received isolated *very heavy / extremely heavy rain* on three days and Ariyalur, Pudukkottai, Salem, Tiruchirapalli, Kanyakumari, Nilgiris, Virudhunagar and Dindigul districts reported isolated *very heavy rain* on 1 or 2 days. *Extremely heavy* rain occurred at isolated places over Coimbatore and Tirunelveli districts on 15<sup>th</sup>, 16<sup>th</sup> & 17<sup>th</sup> August. Highest rainfall of 31 cm/day was recorded at Valparai PTO on 16<sup>th</sup> August.

In CAP, East Godavari, West Godavari, Srikakulam and Krishna districts recorded isolated *very heavy / extremely heavy* rainfall activity on 8 days during the season (28<sup>th</sup> June, 3<sup>rd</sup>, 15<sup>th</sup> & 21<sup>st</sup> July and 11<sup>th</sup>, 13<sup>th</sup>, 15<sup>th</sup> & 20<sup>th</sup> August). Highest rainfall of 39 cm/day was recorded at Koida in West Godavari district on 11<sup>th</sup> August.

In Telangana, isolated *very heavy / extremely heavy* rainfall occurred mainly in the month of August (11<sup>th</sup>, 12<sup>th</sup>, 16<sup>th</sup>, 17<sup>th</sup>, 20<sup>th</sup> & 21<sup>st</sup>) in the districts of Mancherial, Khammam, Badradri Kothagudem, Peddapalle, Adilabad, Jayashankar Bhupalpally, Jagtial, Warangal – Rural, Nirmal, Karimnagar, Nizamabad, Kumarem Bheem & Suryapet districts. Also, isolated *very heavy* rain occurred on 8<sup>th</sup> June and 22<sup>nd</sup> Sep in Mancherial and Adilabad districts respectively. Highest rainfall of 27 cm/day was recorded at Luxettipet in Mancherial district and Ramagumdam in Peddapalle district on 12<sup>th</sup> August.

Rayalaseema reported three days of isolated *very heavy* rain (3<sup>rd</sup>-4<sup>th</sup> June and 17<sup>th</sup> Sep) during the season. There was only one very heavy rainfall report from NIK (Khajuri in Kalaburgi district reported 14 cm of rainfall on 8<sup>th</sup> June) during the season.

The spatial distribution of *very heavy* to *extremely heavy* 24-hr rainfall that occurred on 12<sup>th</sup> Aug over Telangana and during 14<sup>th</sup>-16<sup>th</sup> Aug 2018 over Kerala as depicted by IMD-NCMRWF GPM satellite-Gauge merged rainfall is presented in Fig.6.



Fig.6 GPM satellite-Gauge merged rainfall in cm depicting very heavy(12-20 cm/day) to extremely heavy( $\geq 21$  cm/day) rainfall at isolated places over TEL on  $12^{\text{th}}$  Aug and in CK,SIK & KER during  $14^{\text{th}} - 16^{\text{th}}$  Aug 2018

### 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 2018 are depicted in Fig.7. The SPI indicates many districts in NIK & RYS, some districts in TN, TEL, SIK and isolated districts in CAP and KER and Lakshadweep became *mildly/moderately/severely/extremely dry* at the end of the season. Many districts in KER & CK, some districts in TEL & CAP and isolated districts in TN and SIK along the western ghats and adjoining areas came under *mildly/moderately/severely/extremely wet* category.



Fig.7 Standardised Precipitation Index (SPI) over the SP region during Jun-Sep 2018

### 2.8 Chief synoptic features

*Onset phase*: Onset of SWM 2018 over Kerala took place in association with the formation of a well-marked low pressure area over southeast Arabian Sea off Kerala – Karnataka coasts and another low pressure area over east central Bay of Bengal and neighbourhood and strengthening and deepening of cross-equatorial flow on 28<sup>th</sup> May. The resultant enhanced convection and rainfall caused the advance of southwest monsoon over Lakshadweep, most parts of Kerala,

some parts of Tamil Nadu on 29<sup>th</sup> May. Mean sea level pressure analysis as on 29<sup>th</sup> May / 0300 UTC is shown in Fig.8a.



Fig.8a Mean Sea level pressure analysis as on 29th May 2018 / 0300 UTC

*Monthly features:* Fig.8b depicts the 850, 500 and 250 hPa wind anomaly during the months of June, July August and September 2018.

In June, at 850 hPa level, anomalous anticyclonic circulation was observed over eastern parts of the country. At 500 hPa level, anomalous westerlies prevailed over the peninsula. At same level, an anticyclonic circulation was observed over the northern and central parts which was more marked at the 250 hPa level.

In July, at 850 hPa level, stronger than the normal westerlies over the peninsula and stronger than the normal easterlies over the northern parts indicating active monsoon trough condition were observed. At 500hPa level, an anomalous anti cyclonic circulation was observed over southwest peninsula and adjoining Arabian Sea. At 250 hPa level, an anomalous anti

cyclonic circulation over the northern and northeastern parts and cyclonic circulation over the southeast Arabian sea were observed.

In August, at 850 hPa level, an anomalous cyclonic circulation over the northwest Bay of Bengal was observed. At the same level stronger than the normal southwesterlies over the peninsula and stronger than the normal easterlies over the northern parts indicating strong monsoon circulation were observed. These anomaly patterns extended up to 500 hPa level also. Also, at 850 hPa level, an anomalous anti cyclonic circulation over the southeast Arabian sea enhancing the southwesterlies off the west coast of India was observed. At 250 hPa level an anomalous anti cyclonic circulation was observed over the northeastern/northern parts of the country.

In September, at 850 hPa level, anomalous easterlies over the peninsula and over the central parts anomalous westerlies indicating subdued monsoon condition were observed. At 500 hPa level, an anomalous cyclonic circulation was observed over the northwest region. At 250 hPa level, an anomalous anti cyclonic circulation was observed over the eastern and northeastern region.

*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 upto 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.

Mean sea level pressure and upper air streamline analysis based on 15-08-2018/0300 UTC depicting the presence of off-shore trough and strengthening of westerlies under the influence of the formation of Depression over the Bay of Bengal off Odisha coast tilting southwards with height is shown Fig.8c(i-iii). Widespread rainfall over KER, LAK, CK, NIK, SIK and CAP and fairly widespread rainfall over TN & RYS with vigorous monsoon conditions over KER & TN was realized on 15-08-2018 with isolated extremely heavy rainfall occurrence over KER, SIK & TN.



Fig.8b: 850hPa, 500 hPa& 250 hPa wind anomalies over Indian region during SWM 2018 (Source: Climate Diagnostic Bulletin of India, IMD Pune)



(Fig.8b contd.)



Fig.8c (i) Mean sea level pressure analysis chart based on 15-08-2018/0300 UTC and (ii-iii) upper air streamline analysis based on 15-08-2018/0000 UTC



Fig.8c (contd.)

*Chief synoptic scale systems:* During the SWM 2018 season, 6 major low pressures systems – (i) Depression during  $10^{th}-11^{th}$  June, (ii) Depression during  $21^{st}-22^{nd}$  July, (iii) Depression during  $7^{th}$  -8<sup>th</sup> August, (iv) Depression during  $15^{th}$  -17<sup>th</sup> August, (v) Deep Depression during  $6^{th}$  -7<sup>th</sup> September and (vi) cyclonic storm *Daye* during  $19^{th} - 22^{nd}$  September. All these systems formed over Bay of Bengal and moved westward across central India. The tracks of these systems are presented in the Fig. 8d. Of these systems, the Depression during  $15^{th} - 17^{th}$  August and the cyclonic storm Daye during  $19^{th}$  -22<sup>nd</sup> September contributed towards rainfall over the SP region (CAP / TEL) during the season. Associated with the formation and movement of the depression during  $15^{th}$  -17<sup>th</sup> August, widespread rainfall activity occurred over CAP during  $14^{th}$  -16<sup>th</sup> August with active monsoon conditions on  $14^{th}$  and  $15^{th}$  August and over TEL during  $16^{th}$  &  $17^{th}$  August with vigorous monsoon conditions on  $16^{th}$  and active monsoon conditions on  $17^{th}$ . Associated with the passage of the cyclonic storm *Daye*, fairly widespread to widespread

rainfall activity occurred over CAP & TEL on  $21^{st}$  and  $22^{nd}$  September with active monsoon conditions over CAP on  $21^{st}$  and over TEL on  $22^{nd}$  September.



Fig.8d: Tracks of depressions and cyclonic storms during the SWM 2018

### 3. Heavy rainfall episodes and flood situation in Kerala during 2<sup>nd</sup>-3<sup>rd</sup> weeks of Aug 2018

The week by week monsoon performance over various districts of Kerala and over Lakshadweep from 1<sup>st</sup> June to 15<sup>th</sup> August 2018 is presented in Table-8a.

It is noted that there were three major rainfall weeks – (i) 7-13 Jun, (ii) 12-18 Jul & (iii) 9-15 Aug 2018. Whereas 9 districts received *excess to large excess* rainfall during the week 7-13 Jun, all the districts except Kasargod (13/14) received *excess to large excess* rainfall during the week of 12-18 July and subsequently during the week 9-15 Aug, all the 14 districts of Kerala received *largely excess* rainfall. During all these three weeks large excess rainfall was realized over the western ghat areas. Idukki district received *excess* rainfall of more than 200% i.e., 217%, 233% & 438% excess respectively during these three weeks. Palakkad district received 196%, 135% & 322% excess; Malappuram, 93%, 99% & 405% excess and Wayanad, 182%,

66% & 299% during the same periods respectively. In contrast, during these three weeks, Lakshadweep came under *deficient* (20 to 59% deficiency) to *largely deficient* ( $\geq$  60% deficiency) category.

SN	DISTRICT	Week ending 06-06-18	Week ending 13-06-18	Week ending 20-06-18	Week ending 27-06-18	Week ending 04-07-18	Week ending 11-07-18	Week ending <b>18-07-18</b>	Week ending 25-07-18	Week ending 01-08-18	Week ending 08-08-18	Week ending 15-08-18
1	ALAPPUZHA	22	-44	13	13	-62	-11	182	-8	35	11	195
2	ERNAKULAM	-31	59	31	16	-50	48	224	21	30	-38	124
3	IDUKKI	-50	217	-11	-32	-51	33	233	69	20	-1	438
4	KANNUR	-50	90	9	-20	-30	-7	35	26	-47	-17	144
5	KASARGOD	-41	41	-28	-1	-32	-19	-20	3	-77	-41	91
6	KOLLAM	-3	14	27	-30	-39	-12	192	-37	45	11	479
7	КОТТАУАМ	22	48	35	14	-60	62	230	10	7	-24	135
8	KOZHIKODE	-58	72	42	-1	-39	-6	108	32	-38	-29	205
9	MALAPPURAM	-30	93	82	-28	-59	22	99	15	5	0	405
10	PALAKKAD	-3:	196	68	-32	-53	69	135	0	25	19	322
11	PATANAMTHITTA	-2	3 7	44	-20	-62	-1	159	2	9	19	217
12	THIRUVANANTHAPURA	M 3'	6	10	-28	-78	-5	59	-60	193	-12	617
12	THRISSUR	-4(	12	26	-46	-64	-3	100	-18	-36	-5	76
14	WAYANAD		182	43	-64	-67	49	66	-10	-52	-18	299
				LAKSH	ADWEE	Р				I		
1	LAKSHADWEEP	-3	-71	9	-89	-1	-7	-51	-72	-87	-92	-53
Lege	end		argely def	ficient			Norma	!			Excess	
			Deficie	nt						La	irge exc	ess

Table-8aDistrict-wise week by week departures from normal (%) for the period 01 Jun-15 Aug 2018

During the 79 day period from 01 Jun to 18 Aug 2018, there have been 52 days of heavy rainfall occurrence over Kerala. District-wise details of number of days of heavy rainfall occurrence (*Heavy rain* (*H*): 7-11 cm; very heavy rain (VH): 12-20 cm; Extremely heavy rain (EXH):  $\geq 21$  cm) are presented in Table-8b. It is noted that Idukki district experienced maximum number of heavy rainfall days (30 days with 4 days of *H*-EXH rainfall, 7 days of *H*-VH rainfall and 19 days of *H* rainfall) followed by Wayanad, Malappuram and Palakkad with 29 days, 26 days and 24 days of heavy rainfall occurrence respectively. All these 4 districts (Idukki, Wayanad, Malappuram and Palakkad) are located mainly in the western ghat section.

### Table-8b

		1				1	1			1	1		
	Thiruvananthapuram	Kollam	Pathanamthitta	Alappuzha	Kottayam	Ernakulam	Thrissur	Idukki	Palakkad	Malappuram	Kozhikode	Wayanad	Kannur
H (7-11 cm)	3	9	7	13	19	16	14	19	15	20	10	17	14
H-VH (7-20 cm)	1	1	2	4	3	5	4	7	7	2	9	11	5
H-EXH 7- >20 cm	0	0	0	0	1	1	1	4	2	4	1	1	0
Total	4	10	9	17	23	22	19	30	24	26	20	29	19
H: Heav	vy (7-11	cm)	VH: Ver	y heavy	(12-20	cm)		ExH:	Extrem	ely hea	vy (> 20)	cm)	

District-wise details of No. of days of heavy rainfall occurrence during 01-06-2018-18-08-2018

District-wise details of number of stations reporting heavy rainfall on each day and the highest amount of rainfall reported from 01 Jun to 18 Aug are presented in Table-8c.

As seen, Idukki district recorded heavy rainfall events on 11 out of 12 days from 09-20 July with 2 days of *H-VH* rainfall and subsequently on 10 out 11 days during the period 08-18 Aug with 3 days of *H-EXH* rain and 4 days of *H-VH* rain. On 15 Aug, all the fourteen districts in Kerala recorded heavy rainfall events.

The highest amount of **40 cm/day** was recorded at Nilambur in Malappuram district as on 24-hr ending 0830 IST of 09-08-2018. Peermede in Idukki district recorded extremely heavy rainfall on 4 days. The list of extremely heavy rainfall events during 01 Jun to 17 Aug is presented in Table-8d.

# Table-8c:Date-wise & District-wise details of No. of stations reporting heavy rainfall and<br/>(the highest amount recorded in cm)

Date	THIRUVANANTHAPURAM	Kollam	PATHANAMITHITTA	ALAPPUZHA	коттауам	ERNAKULAM	THRISSUR	IDUKKI	PALAKKAD	MALAPPURAM	KOZHIKODE	WAYANAD	KANNUR	KASARGOD
1-Jun														
2-Jun	1(7)													
3-Jun			1 (7)	4 (14)	1 (8)					1 (8)				
4-Jun				1 (8)	1 (13)		1 (7)		1 (7)					
5-Jun					1 (7)									
6-Jun														
7-Jun					1 (9)	1 (8)								
8-Jun					1 (7)		1(7)			1 (7)	3 (15)		4 (14)	2 (17)
9-Jun							1 (9)		1 (3)		1(7)	1 (10)	1 (9)	
10-Jun					1 (9)			4 (12)	5 (13)	1(7)	1 (17)	2 (11)	4 (12)	1 (7)
11-Jun					1 (8)	2 (8)	1 (8)	5 (32)	1 (7)	1 (10)		1 (15)		
12-Jun														
13-Jun						1(7)		1 (9)	2 (18)	1 (17)		1 (15)		
14-Jun				1 (7)	1 (9)	2 (11)	2 (13)		7 (16)	6 (23)	2 (9)	4 (15)	2 (16)	
15-Jun					1 (9)						2 (14)	1 (9)	2 (8)	
16-Jun														
17-Jun														
18-Jun														
19-Jun					1 (7)									
20-Jun			2 (7)	3 (11)	1 (9)	3 (9)	5 (9)			3 (9)	1 (11)	1 (8)		2 (11)
21-Jun				3 (9)	2 (9)	5 (12)				1 (8)	2 (16)		1 (7)	2 (10)
22-Jun						2 (7)								
23-Jun														
24-Jun														
25-Jun														
26-Jun														
27-Jun													1 (8)	1 (8)
28-Jun							1(7)			2 (7)	3 (14)	2 (9)	4 (12)	
29-Jun												1(7)	1 (7)	
30-Jun														
1-Jul														
2-Jul														
3-Jul														
4-Jul														
5-Jul														

Date	THIRUVANANTHAPURAM	KOLLAM	PATHANAMTHITTA	ALAPPUZHA	коттахам	ERNAKULAM	THRISSUR	IDUKKI	PALAKKAD	MALAPPURAM	KOZHIKODE	WAYANAD	KANNUR	KASARGOD
6-Jul														
7-Jul										2 (8)		4 (11)	2 (8)	
luL-8											1 (8)	1 (10)	1 (7)	1 (10)
9-Jul					1 (10)			2 (7)	4 (9)			2 (11)		
10-Jul			1 (8)	2 (8)	4 (10)	6 (15)	1 (8)	3 (9)		1 (11)		3 (17)		
11-Jul					3 (13)	1 (16)	3 (9)	4 (12)	9 (13)	5 (8)		3 (15)		
12-Jul				1(7)	1(7)	2 (7)		3 (7)	1(7)	1(7)	1 (13)	2 (12)		
13-Jul						1(7)		2 (10)	1 (8)			1(7)		
14-Jul								1 (8)	2 (10)	1(7)	1 (9)	2 (9)		
15-Jul				2 (10)	1(7)	1 (9)		1(7)						
16-Jul		2 (7)	2 (12)	8(14)	3 (23)	5 (23)	6(11)	5 (20)	2 (9)		1 (8)			
17-Jul						2 (7)	2 (8)	3 (9)	1(7)	1(7)		1(7)		
18-Jul				1(7)	4(11)	4 (10)	5 (11)	4 (9)	2 (7)	3 (9)	3 (15)		3 (9)	
19-Jul							1 (8)				2 (13)		3 (10)	2 (8)
20-Jul								2 (8)			1 (9)		3 (9)	1 (9)
21-Jul													2 (7)	1 (9)
22-Jul													1(7)	
23-Jul														
24-Jul						3 (9)		1 (9)						
25-Jul								4 (9)		1(7)				
26-Jul								1 (8)	1 (8)		1(7)			
27-Jul														
28-Jul														
29-Jul								2 (7)	1 (11)	3 (8)				
30-Jul						1(7)								
31-Jul	3 (11)	1 (8)		3 (13)	1 (8)	2 (17)	1(7)	1 (11)	1 (9)					
1-Aug	1(7)	1 (9)		2 (10)			1(7)	1 (9)	2 (8)	1 (10)				
2-Aug														
3-Aug														
4-Aug														
5-Aug														
6-Aug														
7-Aug														
8-Aug		1(7)	1(8)	2 (8)		1(7)	5 (11)	3 (13)		2 (15)		4 (14)	1 (9)	
9-Aug		1(7)	2 (8)	2 (8)				4 (25)	5 (21)	1 (40)		3(31)		
10-Aug		1(7)				1(7)		2 (16)		1 (9)		1 (7)		
11-Aug								1 (9)						
12-Aug														
13-Aug								2 (11)	1 (8)		1 (9)	2 (8)	1 (8)	
14-Aug								4 (12)	3 (13)	5 (10)	3 (10)	1 (10)		2 (8)
15-Aug	4 (14)	3 (11)	1 (8)	8 (12)	4 (11)	6 (17)	7 (15)	5 (27)	8 (18)	6 (21)	3 (20)	4 (16)	4 (18)	1 (8)
16-Aug		3 (9)	1 (12)	4 (10)	3 (14)	4 (11)	6 (25)	2 (35)	9 (24)	6 (27)	3 (26)	3 (9)		
17-Aug		2 (10)	2 (11)	1 (8)	1 (9)	2 (10)	3 (15)	4 (19)	6 (12)	4 (9)		4 (10)		
18-Aug		1(7)						2 (11)						
	New							11.1.1			_			
Legend	No.of stations reporting 7-11 cm (highes amount reported in cm)				No.of stations reporting 7-20 cm (highest amount reported in cm)				No.of stations reporting 7- more than 20 cm (highest amount reported in cm)					

Date	District	Station-Extremely heavy rainfall amount (cm)
11.06.2018	Idukki	Peermede-32
14.06.2018	Malappuram	Manjeri-23, Nilambur-21
16.07.2018	Kottayam	Kozha-23,
	Ernakulam	Kochi AP-23, Piravom-22
09.08.2018	Malappuram	Nilambur-40
	Wayanad	Mananthavady-31
	Idukki	Peermede-25, Munnar-25, Myladumpara-21
	Palakkad	Palakkad-21
15.08.2018	Idukki	Peermede-27, Idukki-23, Munnar-22,
	Malappuram	Karipur AP- 21
16.08.2018	Idukki	Peermede-35
	Malappuram	Ponnani-27
	Kozhikode	Vadakara-26
	Thrissur	Vellanikkara-25, Enamackel-25, Kunnamkulam-23, Chalakudy-22
	Palakkad	Mannarkad-24, Alathur-23, Ottapalam-21, Thrithala-21

Table-8d: List of extremely heavy rainfall events (rainfall  $\geq 21$  cm/day)

Associated with good rainfall performance, water inflow into most of the water storage reservoirs and dams over Kerala increased substantially leading to filling up of the dams upto the limit of maximum storage capacity.

Though rainfall was the main factor for the flood, local terrain, dam water management, drainage system infrastructure and current status, all played a vital role in the devastation caused. A few photographs depicting the floods and the damages caused are presented in Fig.9a&b.



A section of road is seen washed away following a flash flood at Wandoor in Malappuram district (Source: <a href="http://www.theweek.in/news/india/2018/08/09/kerala-idukki-dam-shutters-opened.html">www.theweek.in/news/india/2018/08/09/kerala-idukki-dam-shutters-opened.html</a> )



A car is seen submerged in flood water after heavy rainfall, at Vythiri in Wayanad district of Kerala on Thursday. (Source: <u>https://www.hindustantimes.com/india-news/</u> dated 10-Aug-2018)

Fig.9a Damages (from media reports)



(Source: www.financialexpress.com/india-news/ dated 13-Aug-2018)



All five shutters of Cheruthoni dam in Idukki opened. (Source: <u>https://english.manoramaonline.com/news/kerala/2018/08/14/</u>)

Fig.9a Contd...



A submerged P.C.Ramamurthy Mandapam on the banks of the Pampa river on the foothills of Sabarimala on 14-Aug-2018 (Source: The Hindu dated 16-Aug-2018)



Palakkad: Rescue workers search for the bodies of missing persons after a landslide, triggered by heavy rains and floods, at Nenmara in Palakkad on Friday, Aug 17, 2018. [Source: <u>https://indianexpress.com</u> dated 22-Aug-2018]

Fig.9a Contd...





Kochi Airport submerged in flood water Fig.9b: Damages (reports from social media)

Synoptically, associated with the above extreme rainfall events, there were no major weather systems over the southeast Arabian sea and the Kerala region. However, under the influence of the formation and movement of 3 Depressions (D) over the north Bay of Bengal (BOB), viz., (i) D over northeast BOB during 10-11 June, (ii) D over northwest BOB during 21-23 July and (iii) D over northwest BOB during 7-8 Aug 2018, the westerly flow across the southern peninsula strengthened. Low level convergence of strong, moist winds from the southeast Arabian sea and

orographic lifting led to extreme precipitation over the western ghat region and the cascading effect of such recurrent activity for a few days at a stretch over the same area during all the three major rainfall weeks ((i) 7-13 Jun, (ii) 12-18 Jul & (iii) 9-15 Aug 2018 culminated in the devastation. It is noted that as on 24-hr ending 0300 UTC of 15.08.2018, all the fourteen districts in Kerala recorded heavy rainfall events.

The following synoptic, dynamical and thermo-dynamical features are noted to be associated with the heavy rainfall occurrence over all the 14 districts of Kerala on 24-hr ending 0300 UTC of 15.08.2018.

(i) Strong westerly flow over the Arabian sea along and off Kerala coast during 13-17 Aug 2018 as indicated by the westerly anomalies in the NCEP reanalysis, Time-longitude plot of zonal wind anomaly averaged over 8-12°N latitude for the period 1-17 Aug 2018 (Fig.10a); strong westerly flow across southern peninsula on 15 Aug under the influence of formation of low pressure systems over the Bay of Bengal and South China Sea is indicated in the NCMWRF unified model analysis and NCEP-FNL 0.25 x0.25 degree data analysis as on 15-08-2018/00 UTC [Fig.10b(i-ii)];

(ii) Convergence of low level winds under the influence of low level circulation over the BOB as suggested by the satellite based CIMSS-low level convergence products as on 14 Aug/1500 UTC and 15 Aug/0000 UTC (Fig.10c);

(iii) Strong ascending motion over the southeast Arabian sea off Kerala coast during 12-16 Aug 2018 as depicted by the NCEP reanalysis, pressure-vertical velocity time-longitude plot [Fig.10d(i)] and strong upward motion over the entire Kerala region on 15 Aug as depicted by the vertical velocity at 850 hPa plot based on NCEP-FNL 0.25 x0.25 degree data as on 15-08-2018/00 UTC [Fig.10d(ii)];

(iv) Cooling of atmosphere over Kerala region in comparison with the adjoining areas and existence of strong horizontal temperature gradient across the western ghats as suggested by the air temperature at 850 hPa (based on NCEP-FNL 0.25 x0.25 degree data) as on 15-08-2018/00 UTC (Fig.10e);

(v) Sharp increase in westerly wind speed near about 77°E longitude (over western ghats) as suggested by the Longitude-Vertical cross-section of zonal wind along 11°N (based on NCEP-FNL 0.25 x0.25 degree data) as on 15-08-2018/00 UTC (Fig.10f );

(vi) Generally strong northerly meridional wind flow across the Kerala region with penetration of southerly winds from the east in the extreme lower levels of the atmosphere over 76-78°E longitudes (Kerala region) leading to convergence due to wind discontinuity as depicted by the Longitude-Vertical cross-section of meridional wind along 11°N (based on NCEP-FNL 0.25 x0.25 degree data) as on 15-08-2018/00 UTC (Fig.10g);

(vii) Strong upward motion over 76-78°E longitudes (Kerala region) right from near surface to the upper troposphere with maximum ascending motion in the layer between 700 hPa and 500 hPa levels as noted from the Longitude-Vertical cross-section of pressure-vertical velocity along 11°N (based on NCEP-FNL 0.25 x0.25 degree data) as on 15-08-2018/00 UTC (Fig.10h)

(viii) Horizontal temperature gradient across 76-78°E longitude at 950-900 hPa levels as observed from Longitude-Vertical cross-section of air temperature along 11°N (based on NCEP-FNL 0.25 x0.25 degree data) as on 15-08-2018/00 UTC (Fig.10i).



Fig.10a: NCEP reanalysis – zonal wind anomaly over the Arabian sea off Kerala coast (60-75°E longitudes & averaged over 8-12°Nlatitude) during 04-17 Aug 2018



Fig.10b: (i) NCMRWF-Unified model, 850 hPa wind analysis and (ii) NCEP-FNL, 850 hPa wind analysis (0.25 x 0.25 deg) as on 15.08.2018/00 UTC



Fig.10c: Low level convergence product as on 14/1500 UTC & 15/0000 UTC of Aug 2018 (Source: University of Wisconsin-CIMSS)



Fig.10d: (i) NCEP reanalysis - Vertical velocity (Pa/s) at 850 hPa level over southeast Arabian sea and southern peninsular region averaged over 8-12°N latitudes during 8-16 Aug 2018 & (ii) NCEP FNL analysis - vertical velocity (Pa/s) at 850 hPa as on 15.08.2018/00 UTC



Fig.10e: NCEP FNL analysis of air temperature (°C) at 850 hPa as on 15.08.2018/00 UTC



Fig.10(f-i): NCEP FNL based Longitude-Vertical cross-section along 11°N latitude of (f) zonal wind, (g) meridional wind, (h) vertical velocity & (i) air temperature as on 15.08.2018/00 UTC (x-axis depicts the longitude & y-axis, the vertical pressure level in Pascals)

All the above factors suggest that the enhanced precipitation over Kerala as on 24-hr ending 03 UTC of 15.08.2018 was mainly due to strengthening of westerly wind flow with sharp increase in the westerly wind speed on the windward side of the western ghats. Wind discontinuity in the extreme lower levels and horizontal temperature gradient in the lower levels leading to baroclinicity also enhanced the instability and upward motion. The ascending motion was limited to the vertical column of atmosphere over the Kerala region and subsidence on either side reiterates the role of orographic lifting in enhancing the precipitation over Kerala.

#### 4. Withdrawal of SWM 2018 from the SP region

Withdrawal of SWM 2018 from the SP region (from the extreme northern parts of Telangana and CAP) commenced on 05<sup>th</sup> October. However under the influence of formation and movement of very severe cyclonic storms Titli (08-13 Oct 2018) over BOB and Luban (06-14 Oct 2018) over AS, further withdrawal of SWM was delayed. With the gradual setting in of northeasterlies along the southeastern coastal areas, SWM withdrew from the entire country on 21<sup>st</sup> October 2018. Fig.11 depicts the withdrawal of SWM 2018 from various parts of the SP region.



Fig.11 Isolines of dates of withdrawal of SWM 2018 over the SP region

### 4. Summary

During 2018, southwest monsoon reached parts of south Bay of Bengal, south Andaman Sea and Nicobar islands on 25<sup>th</sup> May. It advanced over Kerala on 29<sup>th</sup>May, 3 days prior the normal date of 1<sup>st</sup> June and covered the entire southern peninsular India by 9<sup>th</sup> June. Rainfall during the SWM season of June-September 2018 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 704.4 mm which is 98% of its long period average (LPA) of 716.1 mm even though the SWM seasonal rainfall over the country as a whole was 91% of its LPA. Seasonal rainfall over the nine meteorological subdivisions covering the five states and two union territories in the region was excess in one sub division (Kerala), normal in 5 sub divisions (CK, SIK, TN, CAP & TEL) and deficient in 3 sub divisions (LAK, NIK & RYS). The seasonal rainfall figures over the nine subdivisions CAP, RYS, TEL, TN, CK, NIK, SIK, KER, LAK) were 0%,-37%, -2%, -12%, -1%, -29%, +4%, +23%, and -45% respectively.

In the monthly scale, the sub division of LAK came under *deficient* category and TN, under *normal* rainfall category, during all the four months (Jun-Sep) of the season. Excepting the month of June, when RYS & NIK came under *normal* rainfall category, these two sub divisions became *deficient* – *large deficient* during the other three months of the season (July, Aug & Sep). The other five sub divisions of CAP, TEL, CK, SIK & KER received *normal* - *excess* rainfall in June and July. In August, all these five sub divisions received *excess* rainfall with KER coming under *large excess* category (+96%). However, in September, all these five sub divisions ended up *deficient* - *large deficient* with CK & KER recording *large deficiency*.

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 in August. Kerala experienced unprecedented floods in the month of August.

The withdrawal of SWM 2018 from the SP region commenced on  $05^{\text{th}}$  October. It withdrew from the entire region on  $21^{\text{st}}$  October 2018.

## Acknowledgements

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### **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 (subdivision) 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

S No.	Terminology	Rainfall range	Rainfall	Percentile			
		In mm	range				
			In cm				
1	Very light rainfall	Trace -2.4	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	Greater or equal	21 cm or	>99.9			
	rainfall	to 204.5 mm	more				
7	Exceptionally Heavy	When the amou	nt is a value	near about the			
	Rainfall	highest recorded rainfall at or near the station					
		for the month or season. However, this term					
		will be used or	nly when the	actual rainfall			
		amount exceeds	12 cm.				

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