



INDIA METEOROLOGICAL DEPARTMENT

SOUTHWEST MONSOON 2009 END OF-SEASON REPORT

HIGHLIGHTS

- For the country as a whole, the rainfall for the season (June-September) was 77% of its long period average (LPA).
- Seasonal rainfall was 64% of its LPA over Northwest India, 80% of its LPA over Central India, 96% of its LPA over south Peninsula and 73 % of its LPA over Northeast (NE) India.
- Monthly rainfall was 53% of LPA in June, 96% of LPA in July, 73% of LPA in August and 79% of LPA in September.
- The monsoon set in over Kerala on 23rd May, one week before its normal date of 1st June. During 8-20 June, there was hiatus in the advance of the monsoon. However, later the monsoon advanced rapidly and covered the entire country by 3rd July, compared to its normal date of 15th July. As in the previous two years, the withdrawal of monsoon from west Rajasthan was delayed and it commenced only on 25th September compared to its normal date of 1st September.
- Out of 526 meteorological districts for which data are available, 215 districts (41) % of the meteorological districts received excess/normal rainfall and the remaining 311 districts (59%) received deficient/scanty rainfall during the season.
- The operational forecast for monsoon onset over Kerala for this year was correct, which is the fifth consecutive correct forecast for this event since issuing of forecast for the event which started in 2005.
- The operational long range forecast for the seasonal rainfall over the country as a whole and over four homogeneous regions except south peninsula have not been accurate. The forecast for August rainfall over the country as a whole has also not been accurate. All these forecasts were overestimate to the actual rainfall situation. However, the forecast for seasonal rainfall over south Peninsula and that for July rainfall over the country as a whole have been accurate.

1. ONSET OF SOUTHWEST MONSOON

The Southwest monsoon set in over Andaman Sea around its normal date of 20th May. It set in over Kerala on 23rd May, about a week earlier than the normal onset date (1st June).

Subsequent to the onset over Kerala, a Severe Cyclonic Storm (Aila) formed over the Bay of Bengal. In association with it the advance of monsoon over the northeastern states including West Bengal & Sikkim occurred earlier than normal. Thereafter, the cross equatorial flow became weak. After a hiatus of about a week, monsoon further advanced along the west coast and advanced up to around 17°N latitude on 7th June. A prolonged hiatus in the further advance of monsoon occurred during 8th – 20th June, which may be mainly attributed to the weak cross equatorial flow and non formation of low pressure systems over the Bay of Bengal. Severe heat wave conditions prevailed over many parts of northwest, central and adjoining eastern parts during this period.

Associated with the formation of a Depression over the Arabian Sea during 23rd – 24th June, Southwest monsoon advanced as a weak current over some more parts of peninsular India and parts of central India during 21st – 27th June. Subsequent monsoon advance was very rapid and by 30th June, most parts of the country, outside parts of west Rajasthan was covered by the monsoon current. Monsoon covered entire country on 3rd July, about 12 days earlier than its normal date of 15th July, when the interaction between monsoon flow and mid-latitude westerlies resulted in copious rainfall over Rajasthan.

Fig. 1 depicts the isochrones of advance of southwest Monsoon – 2009.

2. CHIEF SYNOPTIC FEATURES

The north-south surface pressure gradient across the country was mostly weak throughout the season. The monsoon trough was also very shallow and during many occasions was situated to north of its normal position. During 30-31 July and 13-19 September, the trough was close to the foothills of Himalayas. The cross equatorial flow was weaker than normal during major part of the season except for a brief period from last week of June to third week of July. Due to these anomalous features, the activity of monsoon low pressure systems (lows and depressions) during this year was very much subdued compared to previous years. Only 4 depressions (2 each formed over the Arabian Sea and the Bay of

Bengal) and 5 low pressure areas formed during the season. The life duration of most of these systems over land was short and therefore did not help in persistent rainfall activity.

During June, two depressions and a low pressure area were formed. The low pressure area which formed over the northwest Bay of Bengal and neighbourhood and dissipated over the northeast Bay of Bengal during 4 -7 June and did not contribute much to the monsoon activity. However, the depressions caused very heavy rainfall along the west coast and Saurashtra & Kutch. One depression formed over the east central Arabian Sea, moved northwards along the west coast and weakened after crossing the south Gujarat coast during 23-24 June. Subsequently the remnant of this system re-emerged over the northeast Arabian Sea and after concentrating again into a depression moved northwards over the land during 25 – 26 June and weakened over Kutch and neighborhood.

During July, the synoptic activity was near normal. Two low pressure areas and a deep depression formed during the month. One of the low pressure areas (13-16 July) and the deep depression (20-21 July) formed over northwest Bay of Bengal, moved west northwestwards along the monsoon trough zone and caused normal to excess rainfall along west coast and over central parts of the country.

In August, only one low pressure area formed. This system (25-29 August) which formed over northwest Bay of Bengal and adjoining coastal Orissa moved west northwestwards and contributed to excess rainfall over the central and peninsular India especially over Gujarat and Rajasthan.

In September, one deep depression and one low pressure area formed. The deep depression which formed over the northwest Bay of Bengal off Orissa coast (5 -7 September) initially moved northwestwards and then westnorthwestwards resulting in active monsoon conditions all along the west coast and central India. The interaction of the remnant of this system with trough in upper air westerlies also caused good rainfall activity over north India. Towards the end of the season, a well marked low pressure area formed over the west central Bay of Bengal and persisted during 28-30 September.

Fig.2. shows the tracks of depressions and deep depressions formed over Indian seas during the season.

3. FLOOD SITUATIONS

During the season, some flood incidents were reported in some states viz., Karnataka, Assam, Meghalaya, Arunachal Pradesh, West Bengal, Orissa, Bihar, Jharkhand, Uttar Pradesh, Uttarakhand, Haryana, Punjab, Himachal Pradesh, Gujarat, Maharashtra, Madhya Pradesh, Kerala and Andhra Pradesh.

4. WITHDRAWAL OF SOUTHWEST MONSOON

Like last two years, this year also there was delay in the withdrawal of southwest monsoon due to rainfall activity over north India in associated with the mid latitude westerly activities. The withdrawal of SW Monsoon from west Rajasthan started only on 25th September (a delay of more than 3 weeks). The normal date of withdrawal to start from extreme western parts of Rajasthan is 1st September. Subsequently, it withdrew from most parts of the northwestern states and from the northern parts of Gujarat on 28th September.

5. RAINFALL DISTRIBUTION

The southwest monsoon season (June to September) rainfall for the country as a whole and the four broad geographical regions are as follows

Region	Actual (mm)	Long Period Average (LPA) (mm)	Actual % of LPA	Coefficient Of Variation (CV) % of LPA
All-India	689.9	892.5	77	10
Northwest(NW) India	392.1	611.7	64	19
Central India	795.4	995.1	80	14
South peninsula	692.9	722.5	96	15
Northeast (NE) India	1037.7	1427.3	73	8

The season rainfall is classified as normal when the actual rainfall is within $LPA \pm CV$. The CV for season rainfall over various regions is given in the table above. Similarly season rainfall is classified as deficient when the actual rainfall is less than $(LPA - CV)$ and as excess when the actual rainfall is more than $(LPA+CV)$. Accordingly the 2009 season rainfall over the country as a whole was deficient (77% of LPA), and was the lowest recorded rainfall in recent

decade. Similarly season rainfalls over NW India (64% of LPA), Central India (80% of LPA), and NE India (73% of LPA) were also deficient and that over South Peninsula (96% of LPA) was normal.

The sub-divisionwise season rainfall is shown in Fig.3. The rainfall recorded over 23 out of 36 subdivisions was deficient. Out of the remaining 13 subdivisions, only 3 subdivisions (Saurashtra & Kutch, North Interior Karnataka and South Interior Karnataka) recorded excess rainfall and remaining 10 subdivisions recorded normal rainfall. Out of 526 meteorological districts for which data are available, 215 districts (41) % of the meteorological districts received excess/normal rainfall and the remaining 311 districts (59%) received deficient/scanty rainfall during the season.

The monthly monsoon rainfall over the country as a whole during all the months was below the respective LPA. However, the rainfall during July (96% of LPA) was within the normal limit. Monsoon rainfall over the country as a whole was 53% of LPA during June, 73% of LPA in August and 79% of LPA during September.

The spatial distribution of monthly rainfall is shown in Fig.4.

In June, large rainfall deficiency was observed over most parts of the country due to prolonged hiatus in the monsoon advance over central and northern parts of the country. During July, rainfall over most of the subdivisions along the foothills of Himalayas and few in the eastern side of the Peninsula were highly deficient. The rainfall over most of the subdivisions along the monsoon trough zone region and along west coast was normal/excess due to the strengthening of monsoon over these regions in association with the passage of fast moving synoptic scale systems from Bay region along the monsoon trough zone. In August rainfall over most of the subdivisions along the west coast and that over NW India & neighboring central India were highly deficient. In September the rainfall over all subdivisions from south Peninsula & neighboring central India and that over few subdivisions from north was normal or excess. Rainfall over other subdivisions was deficient or scanty.

Figures 5 and 6 depict the monsoon rainfall as received week by week and the cumulative rainfall during the season. The weekly rainfalls were below normal during most of the season except four weeks. These

are two middle weeks of July, last week of August and first week of September. The cumulative rainfall distribution shows that the large deficiency in rainfall during early part of the season caused the cumulative seasonal rainfall over the country as a whole to remain below normal by 19% or more during every weeks of the season.

6. LONG RANGE FORECAST OF MONSOON RAINFALL

Based on an indigenously developed statistical model, it was predicted that monsoon will set in over Kerala on 26th May with a model error of ± 4 days. The forecast came correct as the actual monsoon onset over Kerala took place on 23rd May, 3 days earlier than the forecasted date. Thus this is the fifth consecutive correct operational forecast for the monsoon onset over Kerala since issuing of operational forecast for the event which started in 2005.

As per the first stage long range forecast issued on 17th April, the season (June-September) rainfall for the country as a whole was expected to be $96\% \pm 5\%$ of LPA. In the updated forecast issued on 24th June, the forecast for the country as a whole was revised to a lower value of $93\% \pm 4\%$ of LPA. However, the forecast was not correct as the actual area-weighted rainfall for the country as a whole was 77% of LPA, well below the lower limit of forecast value. The forecasts for the July & August rainfall over the country as a whole were 93% & 101% of LPA respectively with a model error of $\pm 9\%$. The Forecast for July rainfall turned out to be correct as the actual July rainfall was 96% of LPA. But forecast for August was not correct as the actual August rainfall was 73% of LPA, which was much less than the lower limit of the forecast. Considering 4 broad geographical regions of India, the season rainfall was expected to be 81% of its LPA over NW India, 99% of LPA over Central India, 92% of LPA over NE India and 93% of LPA over South Peninsula all with a model error of $\pm 8\%$. These forecasts were indicating that the season rainfall over the three geographical regions other than central India to be well below respective LPA values. Particularly the forecasts for NW India and NE India were one standard deviation below the respective LPA values. The actual rainfalls over NW India, central India, NE India and south

Peninsula were 64%, 80%, 73% and 96% of the LPA respectively. Thus although the actual rainfalls were less than the LPA values as expected, the forecast over south Peninsula was only correct. The forecasts for other three regions were not correct as the actual rainfalls were very much less than the lower forecast limits.

The Table below gives the summary of the verification of the long range forecasts issued for the 2009 Southwest monsoon.

Table: Details of long range forecasts and actual rainfall.

Region	Period	Issued on	Forecast	Actual
All India	June to September	17 April, 2009 24 June, 2009	96% \pm 5% of LPA 93% \pm 4% of LPA	77% of LPA
All India	July	24 June, 2009	93% \pm 9% of LPA	96% of LPA
All India	August	24 June, 2009	101% \pm 9%of LPA	73% of LPA
Northwest India	June to September	24 June, 2009	81% \pm 8%of LPA	64% of LPA
Northeast India			92% \pm 8%of LPA	73% of LPA
Central India			99% \pm 8%of LPA	80% of LPA
South Peninsula			93% \pm 8%of LPA	96% of LPA

As a whole, the operational long range forecasts issued for 2009 south-west monsoon season were not very accurate. However, it may be mentioned that other centers in India and abroad preparing experimental forecasts for monsoon rainfall were also could not forecast the 2009 deficient monsoon rainfall correctly.

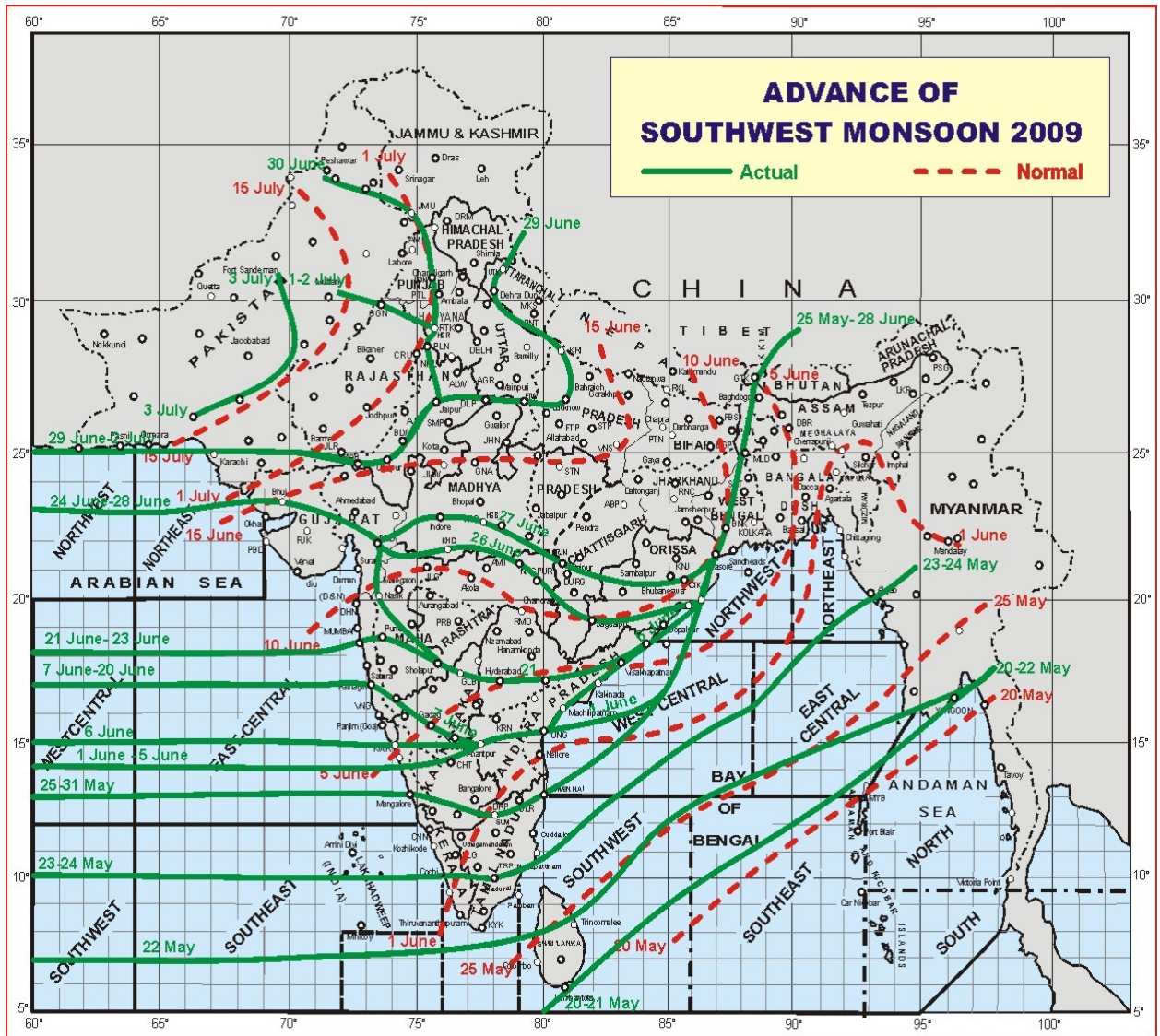


Fig.1: Progress of Southwest Monsoon – 2009

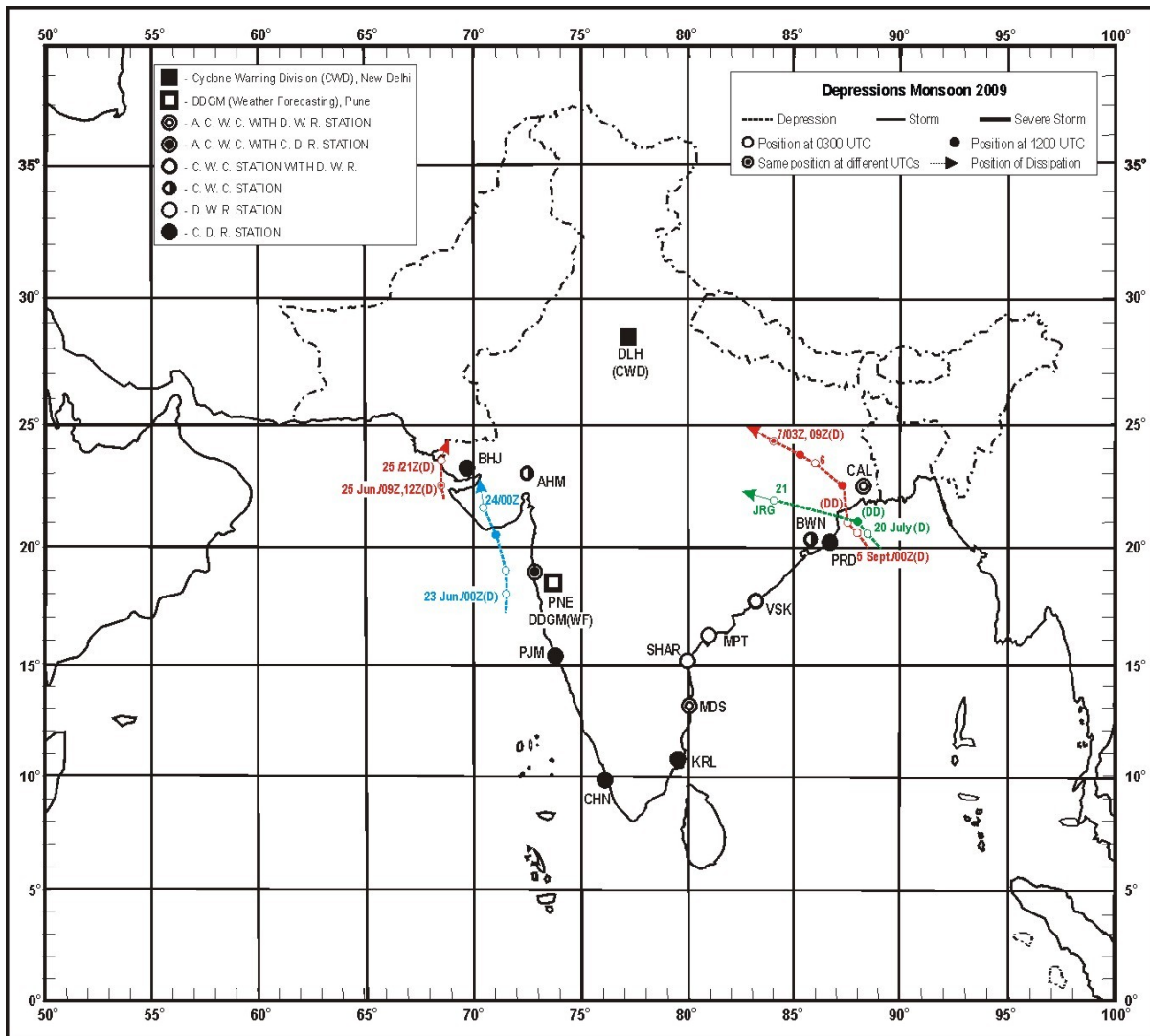


Fig.2: Tracks of the depressions formed over Indian seas during the Southwest Monsoon Season– 2009

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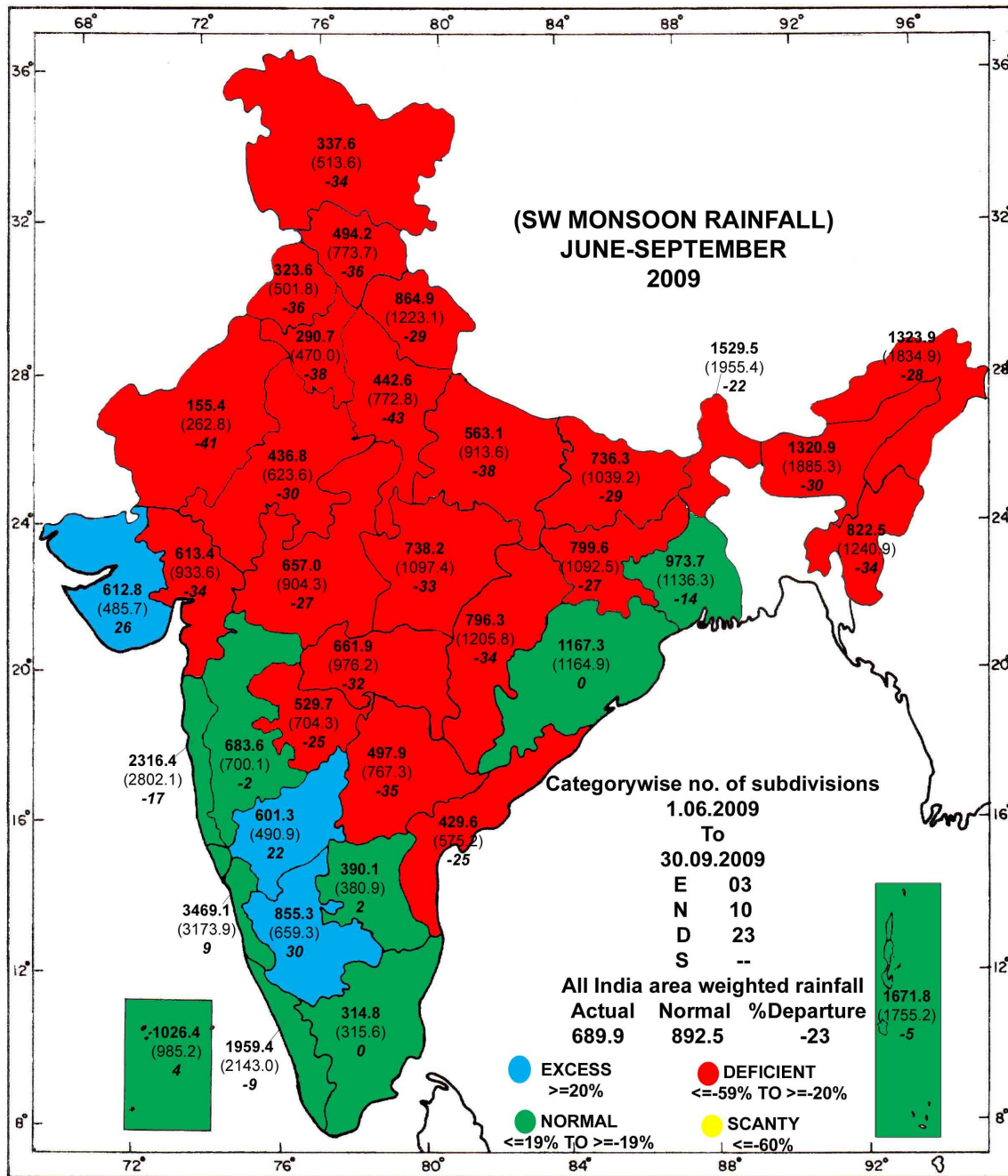
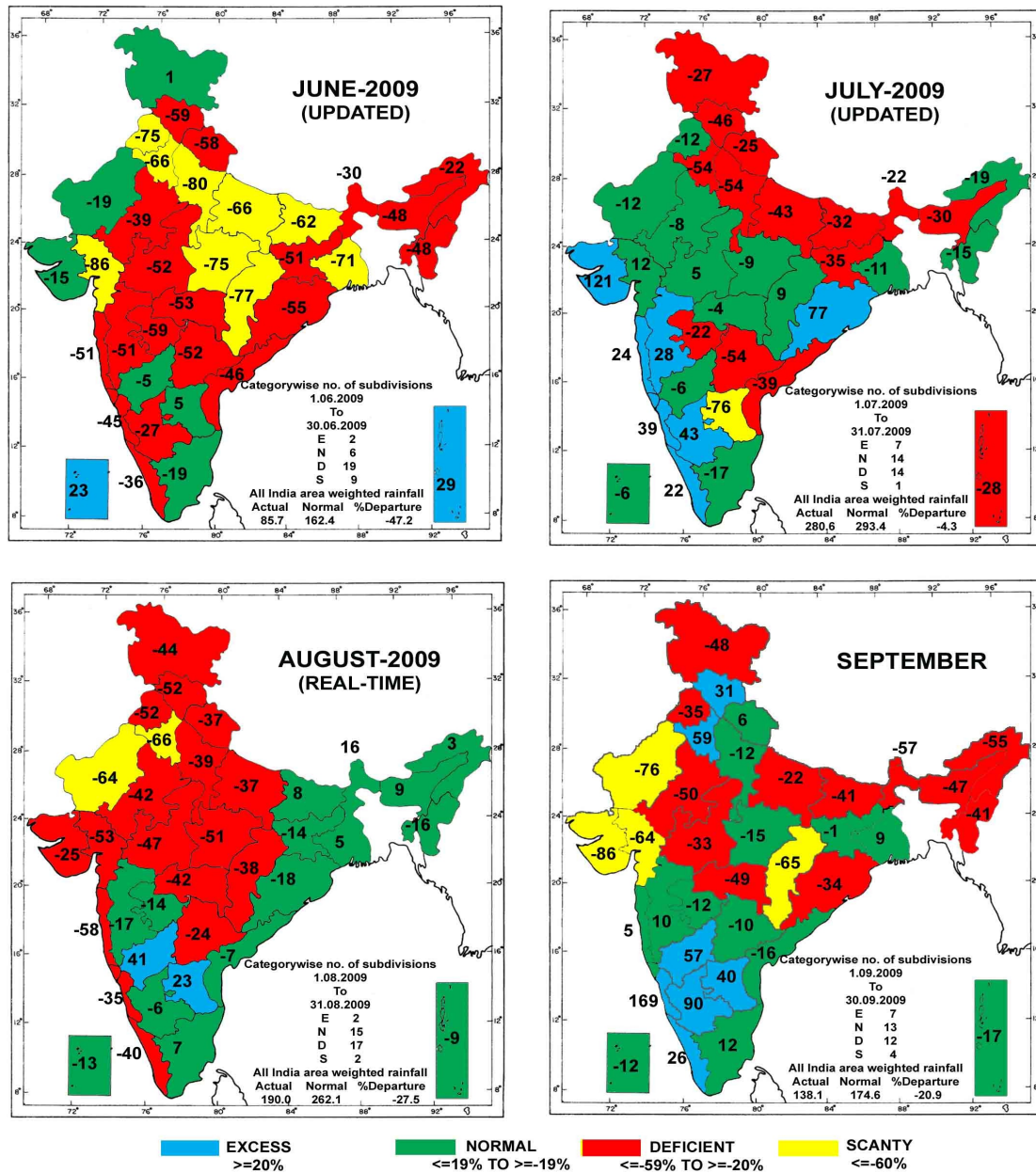


Fig.3: Sub-divisionwise rainfall distribution over India during southwest monsoon season (June to September) – 2009

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(MONTHWISE RAINFALL IN % DEPARTURE)



**Fig.4: Sub-divisionwise monthly rainfall distribution over India
 during southwest monsoon season – 2009**

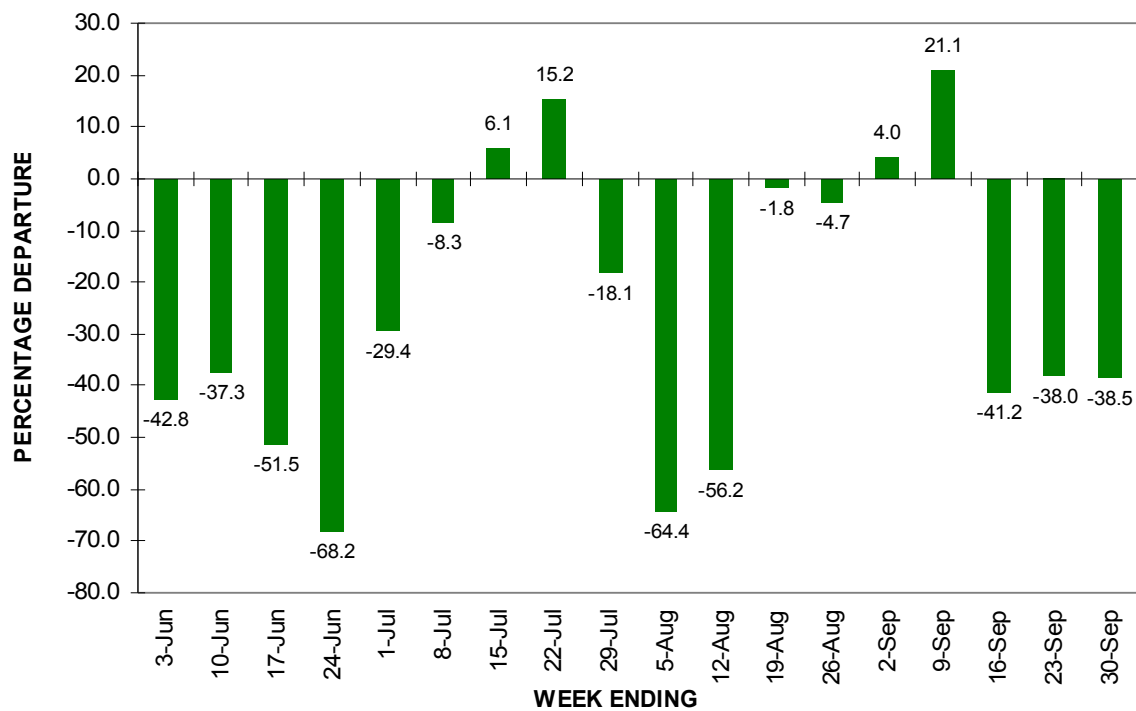


Fig.5: Week - by - Week Progress of the Monsoon Rainfall – 2009

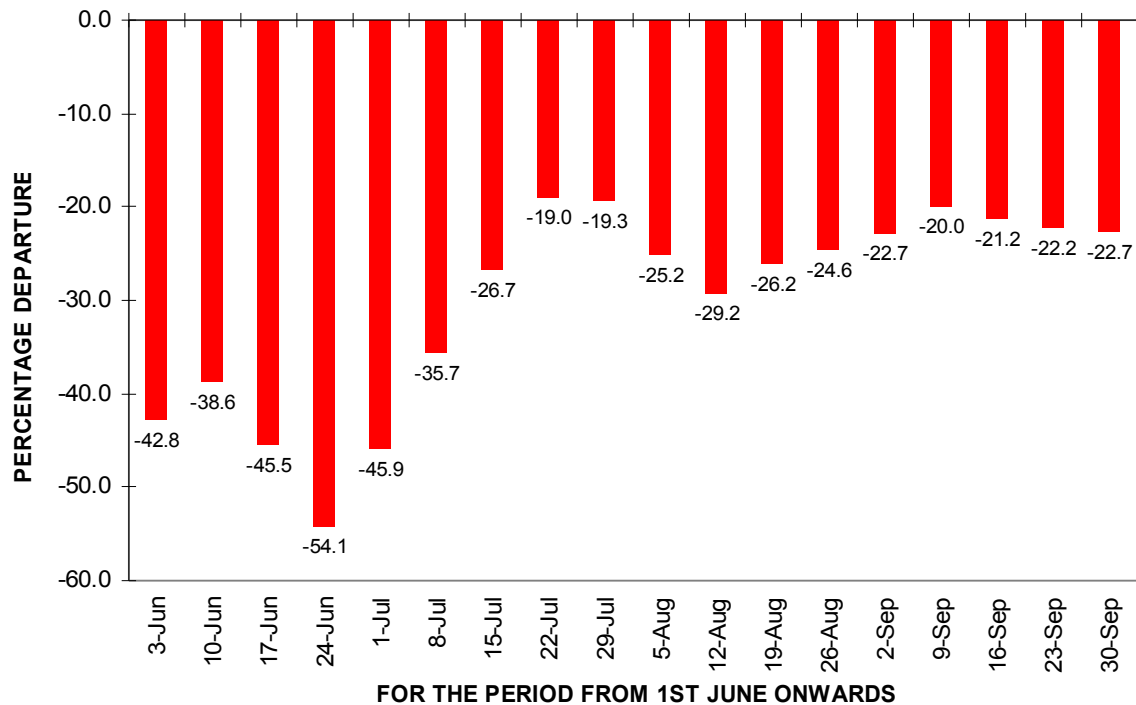


Fig.6: Week - by - Week Progress of the Monsoon Rainfall - 2009 (Cumulative)