Suppressed Surface Heating over northwestern parts of the Country and the ensuing Monsoon Rainfall

During this year, the temperatures have been below normal over north and northwestern parts of India. This has been due to the enhanced activity of western disturbances. These conditions have raised many apprehensions about the possible impact on the subsequent monsoon, if any. In this context, this is an attempt to impart the meteorological knowhow on the probabilities of less surface heating over northwest India (due to the higher frequency of western disturbances during April 2011) influencing the southwest monsoon rainfall and if so up to what extent.

1. The monsoon mechanism

Land-Sea heat contrast is the major causative factor of Indian summer monsoon. Following the northward march of the Sun, the vast land area extending from east Africa to north India including Arabia and Pakistan is heated and an intense surface heat low pressure develops over this area. Corresponding changes also occur in the tropospheric circulation. The pre-monsoon thermal field over the Indian landmass has an important bearing on the land - sea heating contrast in the region, consequently influencing the establishment, advance and overall performance of the Indian Summer Monsoon Rainfall. This land - sea heating contrast is the necessary triggerring mechanism for setting in of the monsoon circulation. Its further sustanance is provided by the latent heat release due to large scale organised convective activity. A schematic representation of monsoon flow is given in Figure 1 below.

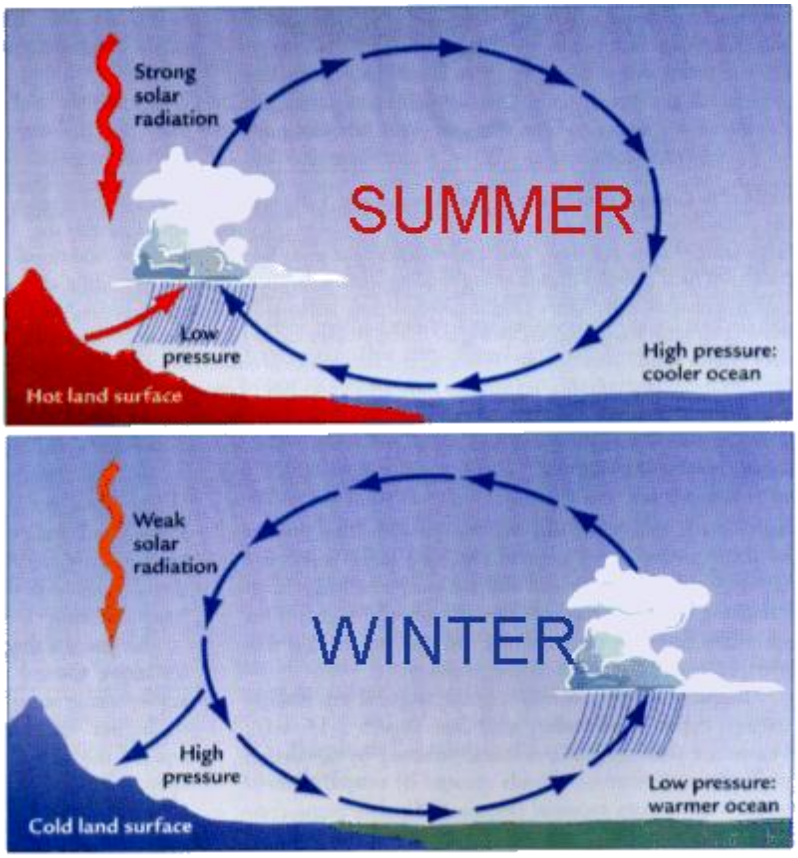

Fig.1

2. Factors influencing the heating up of mainland

Climatologically, the vertical extention of the sub-tropical high pressure belt over the central and northern parts of the country leads to clear skies, permitting more of insolation and sensible heating associated with the apparent northward march of the Sun. The significant heating of the tropospheric column during the pre-monsoon season is influenced largely by sensible heating, adiabatic warming, latent heat release due to precipitation, cold horizontal advection, cloud cover, etc .

With the progress of the hot weather (Pre-monsoon) season, a ‘heat low’ starts developing at the surface and in the lower tropospheric levels over central parts of the country. It gradually shifts northwards. In April, the ‘heat low’ is normally situated over northeast Madhya Pradesh and adjoining south Uttar Pradesh.

However, this normal pattern might show variations under some situations such as widespread precipitation and clouding associated with a series of active western disturbances moving eastwards across the region offsetting the influence of intense solar heating as has been noticed during April 2011.

3. About the western disturbances

Western disturbances are eastward moving upper air troughs in the sub-tropical westerlies which often manifest as cyclonic circulations / troughs in the upper air charts or as closed lows on the surface charts.

These are percieved to be the secondaries of extra tropical depressions which move northeastward from the eastern Mediteranean Sea and are confined within the latitudinal belt 25 - 35^{o}N. These systems infuence the weather over the country all through the year, eventhough the climatological frequency of western disturbances is slightly lower during the pre-monsoon season as compared to that during the winter season.

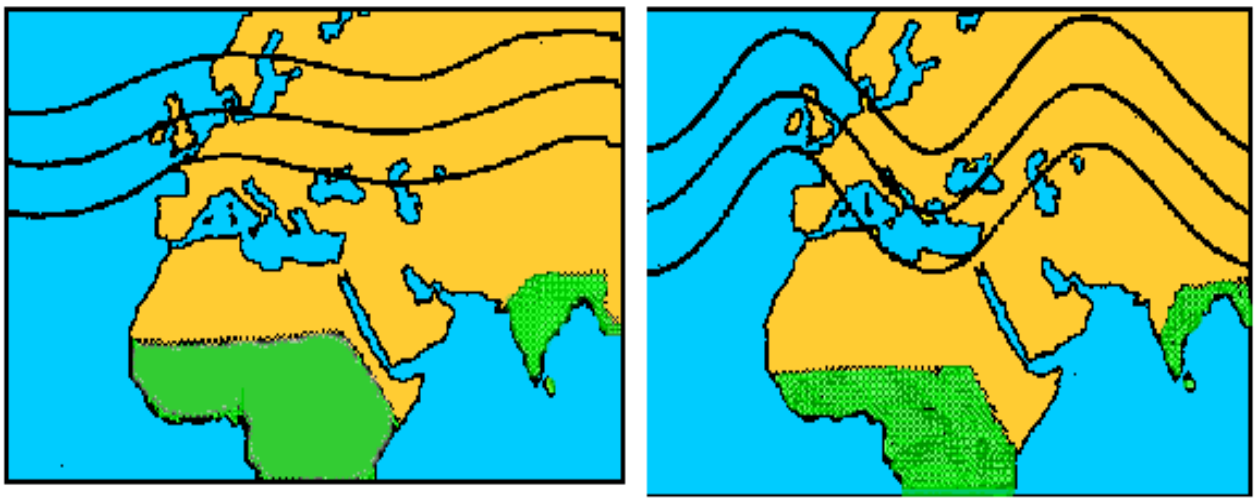

Fig. 2. Schematic diagram showing the wind flow pattern corresponding to High and Low index phases.

The wind flow patterns depicted above (Figure 2) shows two types of general circulation regimes which, in meteorological parlance, are known as high index and low index ciculations respectively. In the latter, the mid-latitude westerly regime becomes more meridional with large amplitude troughs and ridges encircling the globe. In such a situation, when a blocking High is present to the north of India, the westerly systems may move along more southerly latitudes, to the south of the Blocking High and extend well into the Indian Latitudes.

The pre-monsoon season of 2011, so far (up to first week of May) has witnessed the passage of 24 western disturbances.The number of the western disturbances which moved across the country during the pre-monsoon season for the years 1980 – 2010 is given is shown in Figure 3. The frequency includes number of systems noticed as upper

air cyclonic circulations, troughs, low pressure areas on sea level charts as well as induced systems.

4. Temperature situation over nortwest India so far during the current pre-monsoon season as compared to past 30 year period

The mean maximum temperatures for the month of April 2011 have been 1-2 Degree C below normal over most parts of northwest India (Figure 4). There has not been any significant incidence of heat wave conditions in the summer season so far. These conditions were observed over Rajasthan only on a few days during second fortnight of the month. However, a series of western disturbances and the systems induced by them caused weather (including precipitation in the form of snow over the higher reaches of Himalayas) over the north and northwestern parts. It resulted in bringing down the day time heating to normal / below normal ranges during April and till first week of May.

The lower frequency of heat wave occurrences (representing the total number of days in which Severe heat wave / heatwave / hot day conditions prevailed over a particular sub-division) over the meteorological sub-divisions of nortwest India (table below) in April 2011 may be noticed as compared to those during the past 5 years.

Met. Sub-Div./ Year.	West Uttar Pradesh	Uttarakhand	Haryana, Chandigarh & Delhi.	Punjab	Himachal Pradesh	Jammu and Kashmir	West Rajasthan	East Rajasthan
2011	0	0	0	1	0	0	4	0
2010	22	3	29	17	4	6	21	24
2009	3	1	8	4	6	2	9	6
2008	8	0	10	6	2	1	8	5
2007	7	0	18	12	0	2	18	18
2006	4	0	8	5	0	0	11	7

It is seen that this frequency is the lowest during the past 6 years. However, it is not so during the past 30 year period. A detailed analysis of the weather reports during

1980 – 2010 shows that there had been similar years such as 1983, 1985, 1986, 1991 & 1997 in which pre-monsoon season witnessed colder than normal surface temperatures. The years 1983 & 1986 witnessed snowfall over the western Himalayas almost all through the months of March, April & May. Out of these two, the year 1983 was an All-India flood year and 1986 was a deficient monsoon year. During April 1992, though the temperatures reported were above normal over the peninsular India, they were below normal over north India.

5. Results of past analysis relevant to the current investigation

Several authors have investigated the lag-relationships between the surface parameters and monsoon rainfall. Walker (1924) obtained a near zero correlation between the average surface air temperature in May at 15 stations in south Asia and Indian monsoon raqinfall using the data of 1875-1913. Mooley and Paolino (1988) and Parthasarathi *et al.* (1990) have found a significant association between the surface temperature of the pre-monsoon months and monsoon rainfall. Taking cue from this Krishna Kumar *et al*. (1997) analysed the stationwise maximum and minimum temperatures for the winter and pre-monsoon months for the period 1951 – 1980 and found that the spatial patterns of correlation coeffients with the southwest monsoon rainfall are significant only for (i) the maximum temperatures for the month of April over the central and west central parts of the country and over a small region in the north and (ii) the minimum temperatures in all the 3 months of March, April and May over larger parts of the country.

The study by Das *et al*. (2002) reveals that a higher frequency of western disturbances in April leads to delayed advance of monsoon over northwest India, but earlier than normal advance over the eastern parts of north India. This study also brought out that the coeffients of correlation between the western disturbance frequency during the month of May and all India monsoon rainfall are not significant.

6. Mean surface temperature anomaly over northwest India and monsoon rainfall for the period 1980 – 2010

Analysis of the mean surface temperature anomaly over northwest India and All India/Northwest India Summer Monsoon Rainfall for the period 1980 – 2010 are given in Figure 5 and 6, respectively. It may be noticed from these figures that there is no one to one correspondece between the pre-monsoon heating over the northwestern parts and the ensuing rainfall of the southwest monsoon season during the study period. It may be

possible that the relationship established by the previous studies mentioned above does not hold good after the 1980's. Since it had been pointed out by Das *et al*. (2002) that there could be delay in the advance of southwest monsoon over northwest India when there is a high frequency of pre-monsoon western disturbances, an analysis was made for this aspect also. Out of the last 30 years, the years with high WD activity (with more than 40 WDs) were chosen and the advancement of monsoon upto Delhi was studied. There have been seven such years (1980, 1982, 1983, 1984, 1985, 2005 and 2006). In this case also, no one to one relationship was found as out of these seven years the advance of southwest monsoon upto Delhi was delayed in only three years whereas it was normal or early in four years. Therefore, it may be noted that the enhanced westerly activity during the pre-monsoon months causing reduction in the surface temperature over northwest India does not have a one-to-one relationship with either the monsoon season rainfall or the advance of monsoon over the region.

Another aspect of the WD activity this year has been that though their number has been on the higher side, these have not been very active and, therefore, resulted in less than normal precipitation in northwest India. The meteorological sub-division wise rainfall for the season (upto 04 May) given in Figure 7 show that the rainfall has been normal only in Jammu and Kashmir. It has been deficient or scanty in rest of the northwest India.

7. 2008- a recent year with similar cold anomalies

A recent year (2008) also witnessed more than normal western disturbance activity during the premonsoon season. The seasonal rainfall for the Pre-monsoon season (Figure 8) was normal to above normal in majority of the meteorological sub-divisions. Also the anomalies of maximum temperatures for the months of April and May 2008 given in Figure 9 show that maximum temperatures over northwest India were upto only upto one Degree C warmer during April whereas these were two Degree C or more colder than the normal temperatures during May. However, the total seasonl rainfall during the following monsoon season was normal to above normal in all but three meteorological sub-divisions of the country (Figure 10). The All India Monsoon Rainfall was 98% of the long period average (LPA) and the rainfall over Northwest India was 107% of its long period average. The southwest monsoon set in over Kerala on 31 May (one day ahead of its normal date). Its advancement upto the northwestern parts of the country was faster than the normal. It advanced upto New Delhi on 15 May (two weeks ahead of the normal date).

8. Conclusions.

(i) There has been enhanced western disturbance activity (in terms of the no. of weather producing western disturbances) over the nortwestern and northern parts of the country, during April 2011.

(ii) However, the lesser heating up of the region is not un-precedented as there had been similar weather and resultant temperature scenario in the past, such as during the years 1983, 1985, 1986,1991, 1997 and 2008 during the span of past 30 years.

(iii) No one-to one relationship could be observed between surface heating of nortwest India during the pre-monsoon period and the subsequent monsoon rainfall.

9. References.

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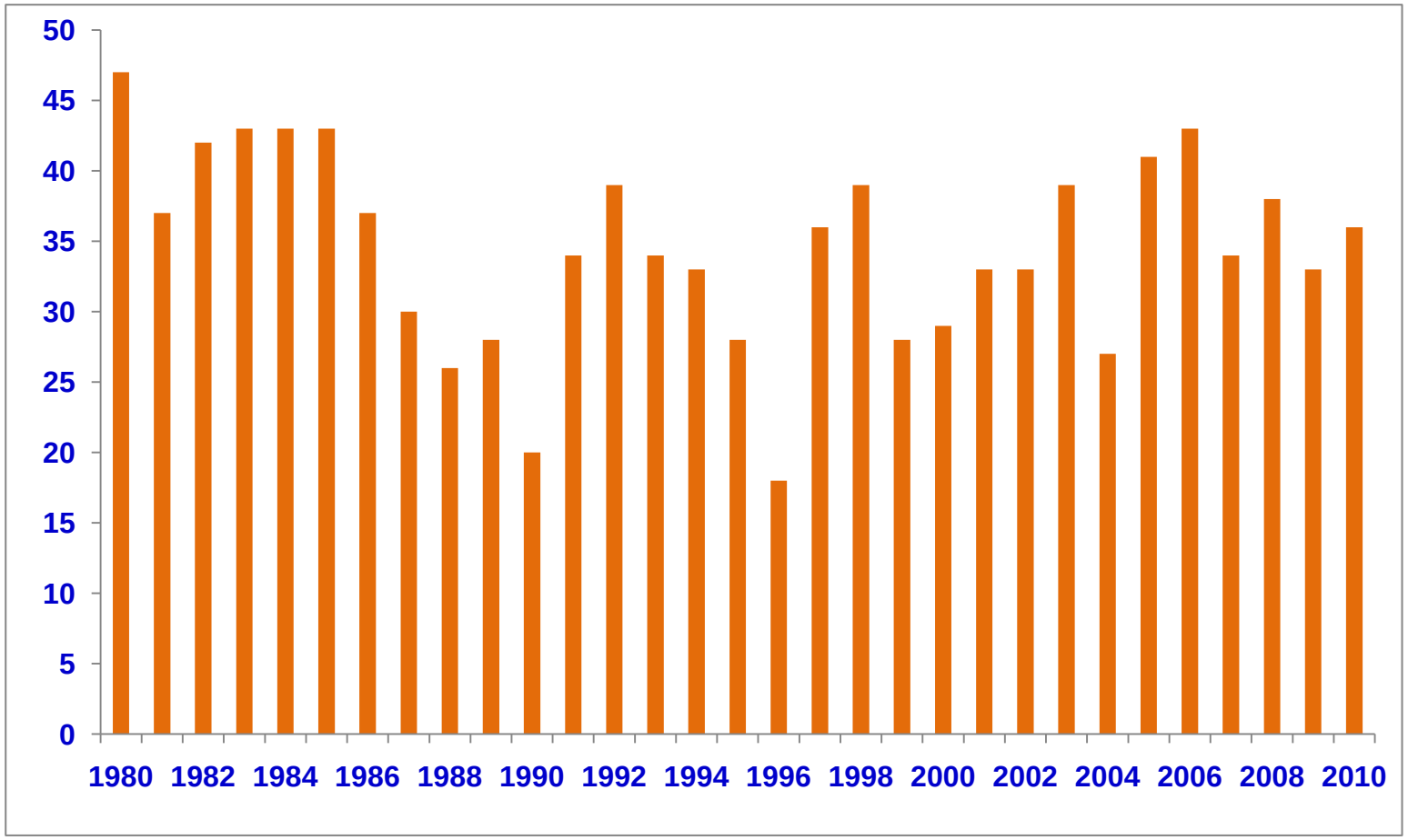


Fig.3. Number of systems in westerlies affecting the country during the pre-monsoon season (1980-2010).

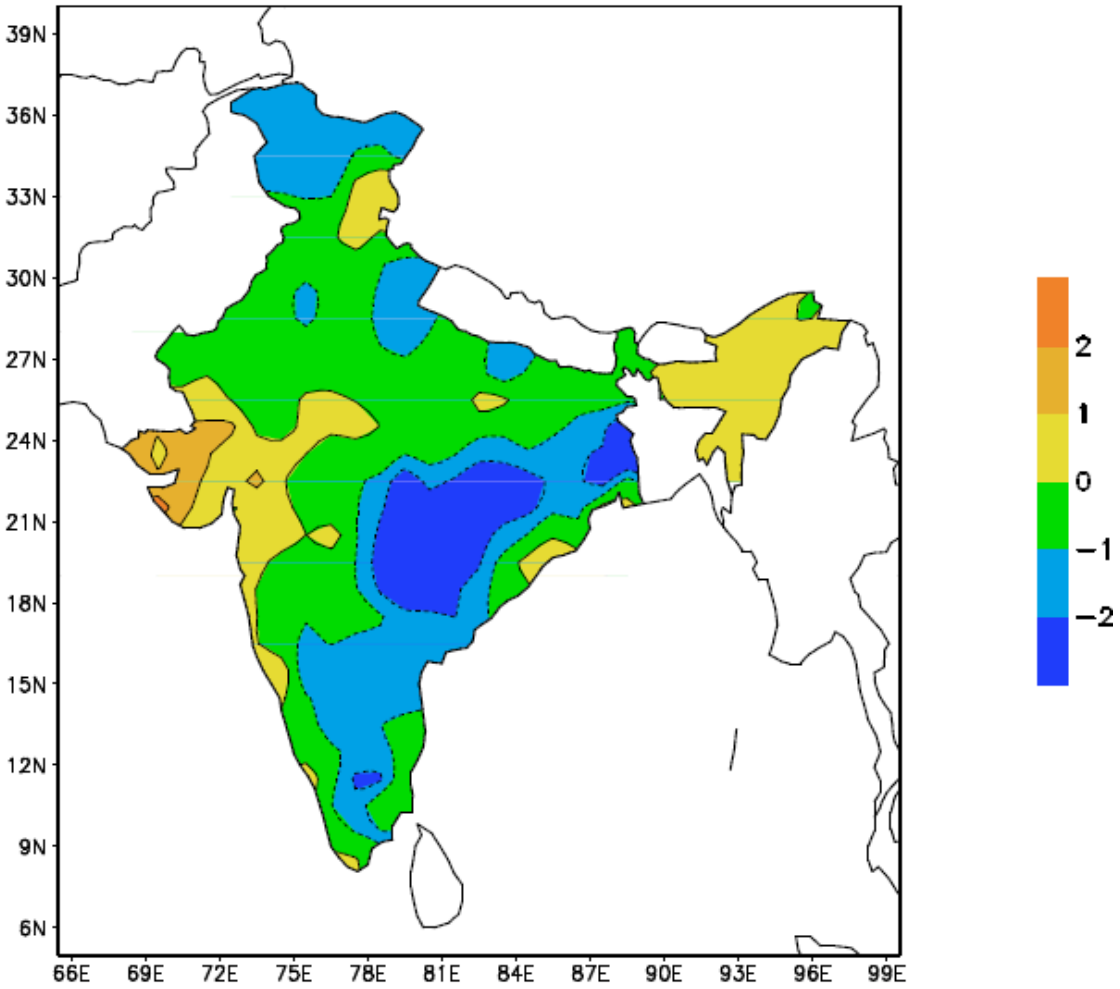


Fig. 4. Mean Maximum Temperature Anomaly during April 2011

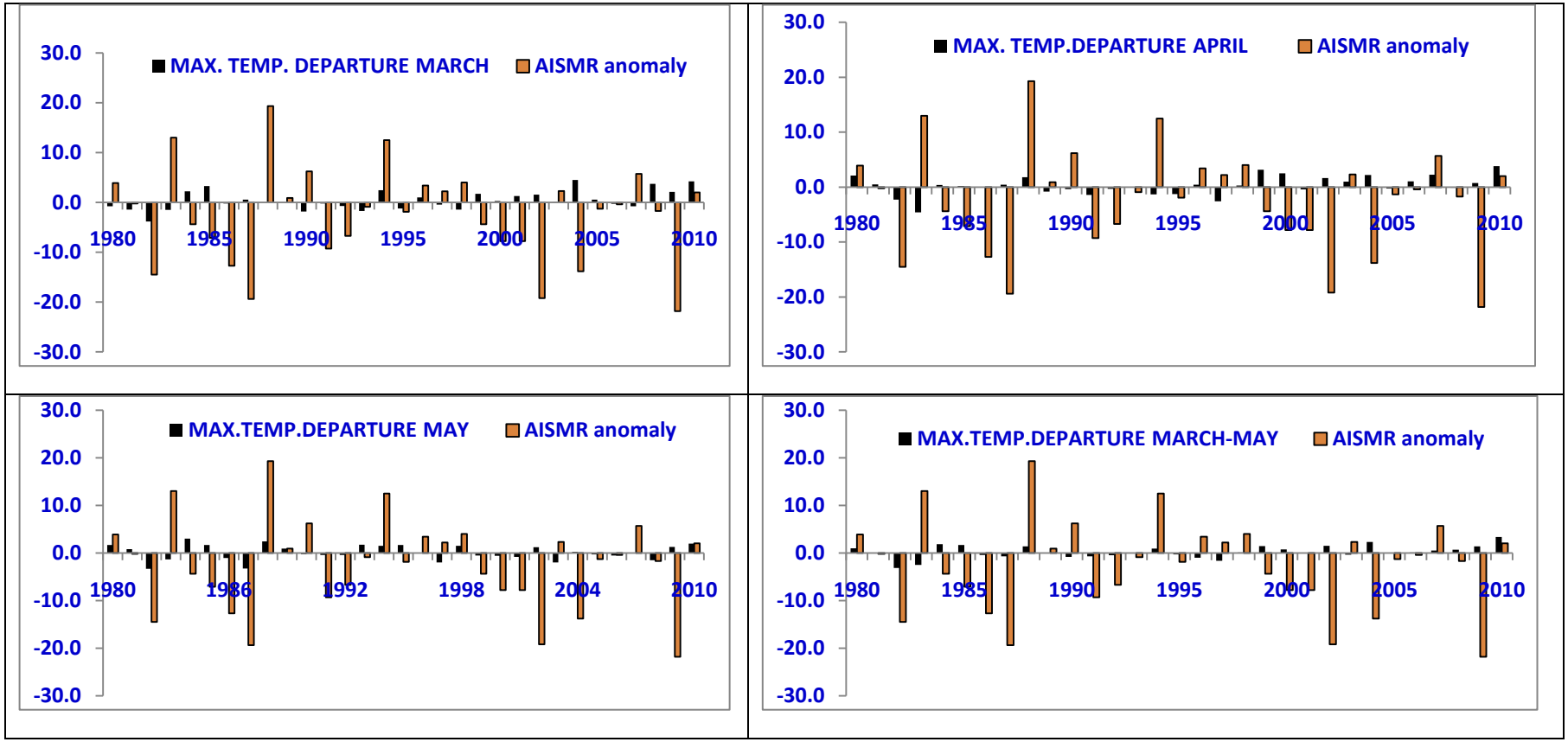


Fig. 5. Maximum temperature anomalies averaged over northwest India during March, April, May and March to May and the corresponding seasonal all India summer monsoon rainfall.

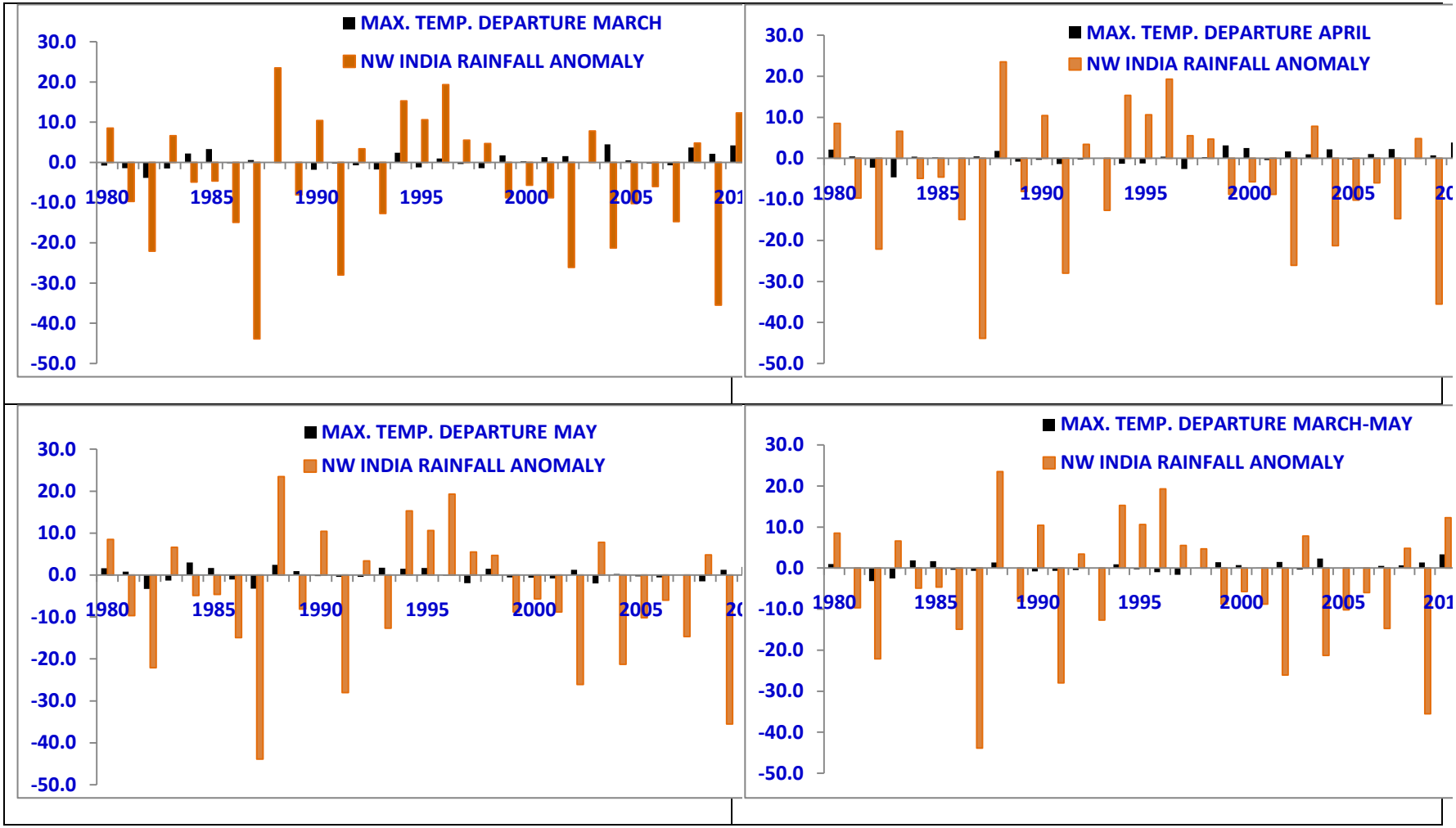


Fig. 6. Maximum temperature anomalies averaged over northwest India during March, April, May and March to May and the corresponding seasonal summer monsoon rainfall over northwest India.

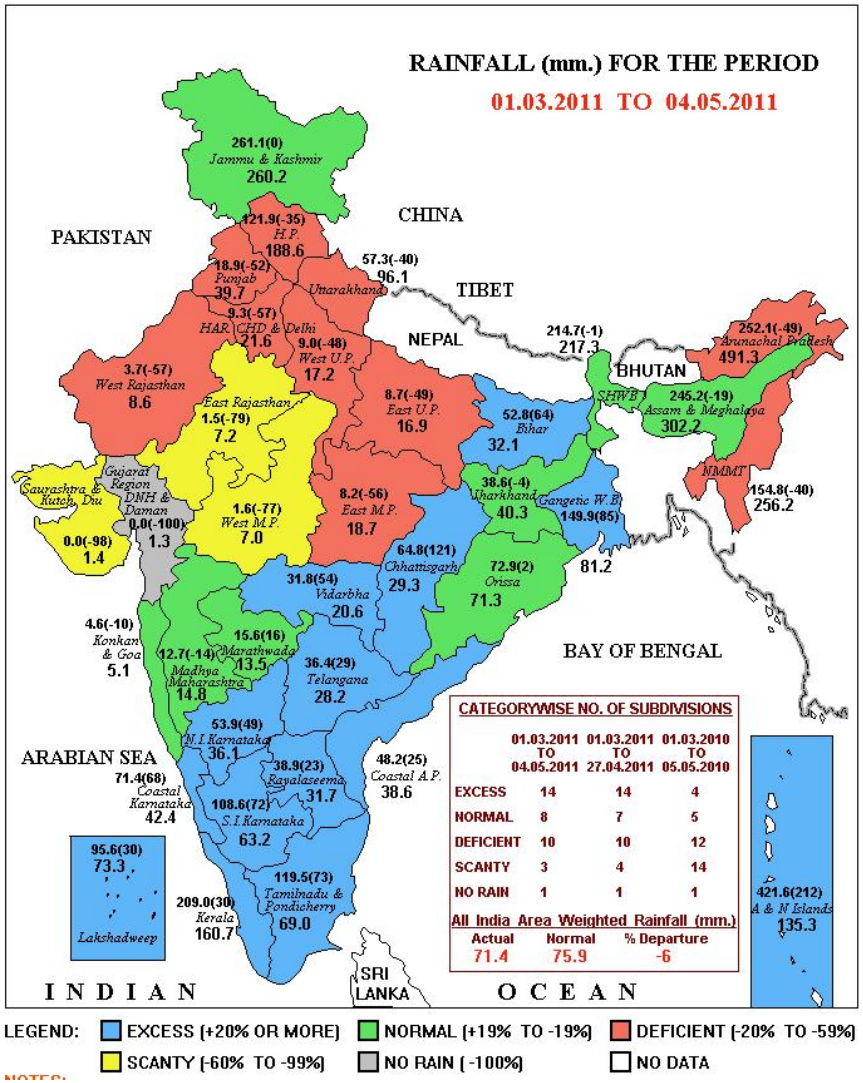


Fig. 7. Sub-division wise Rainfall during Pre-monsoon season 2011 (upto 04 May).

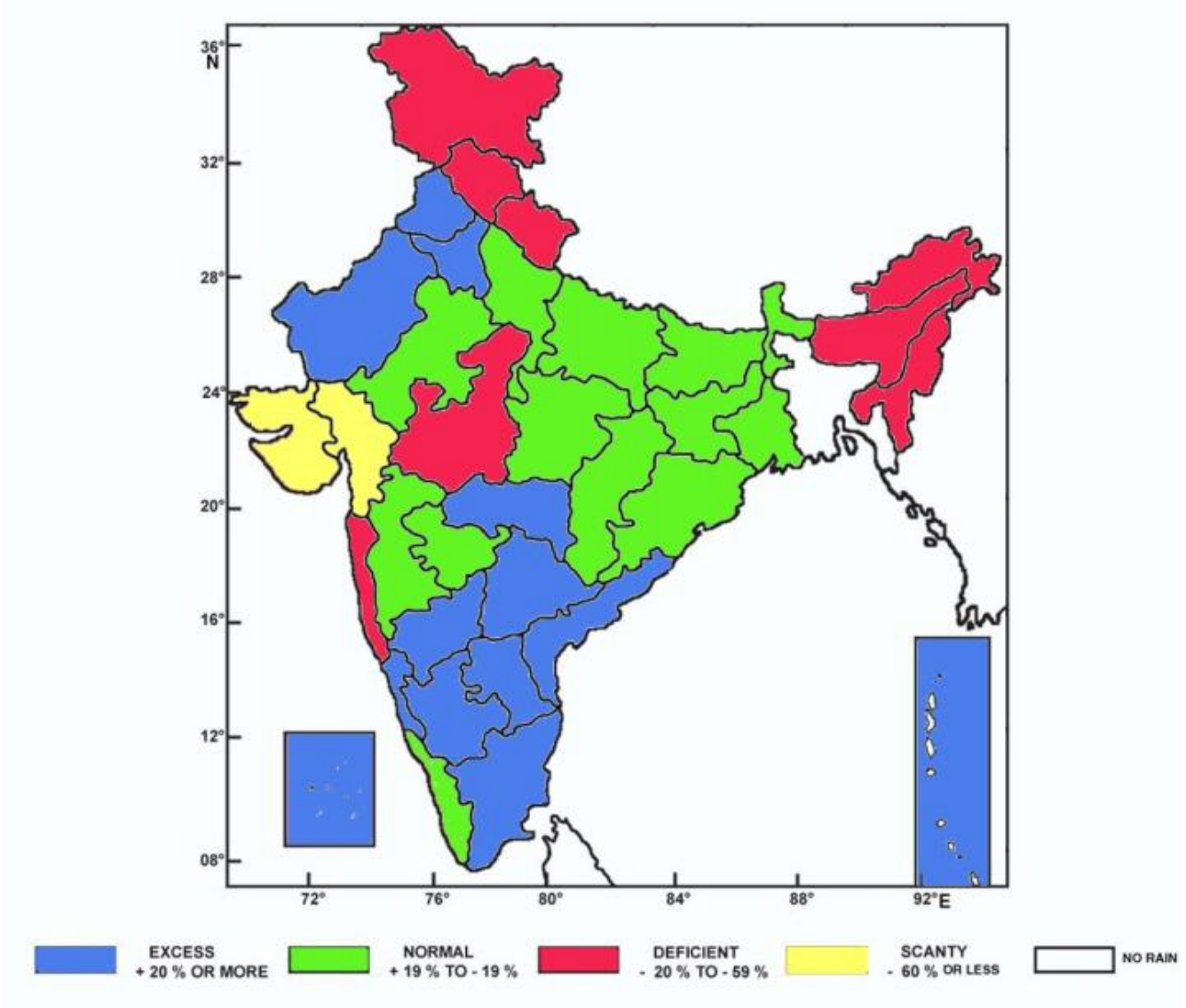
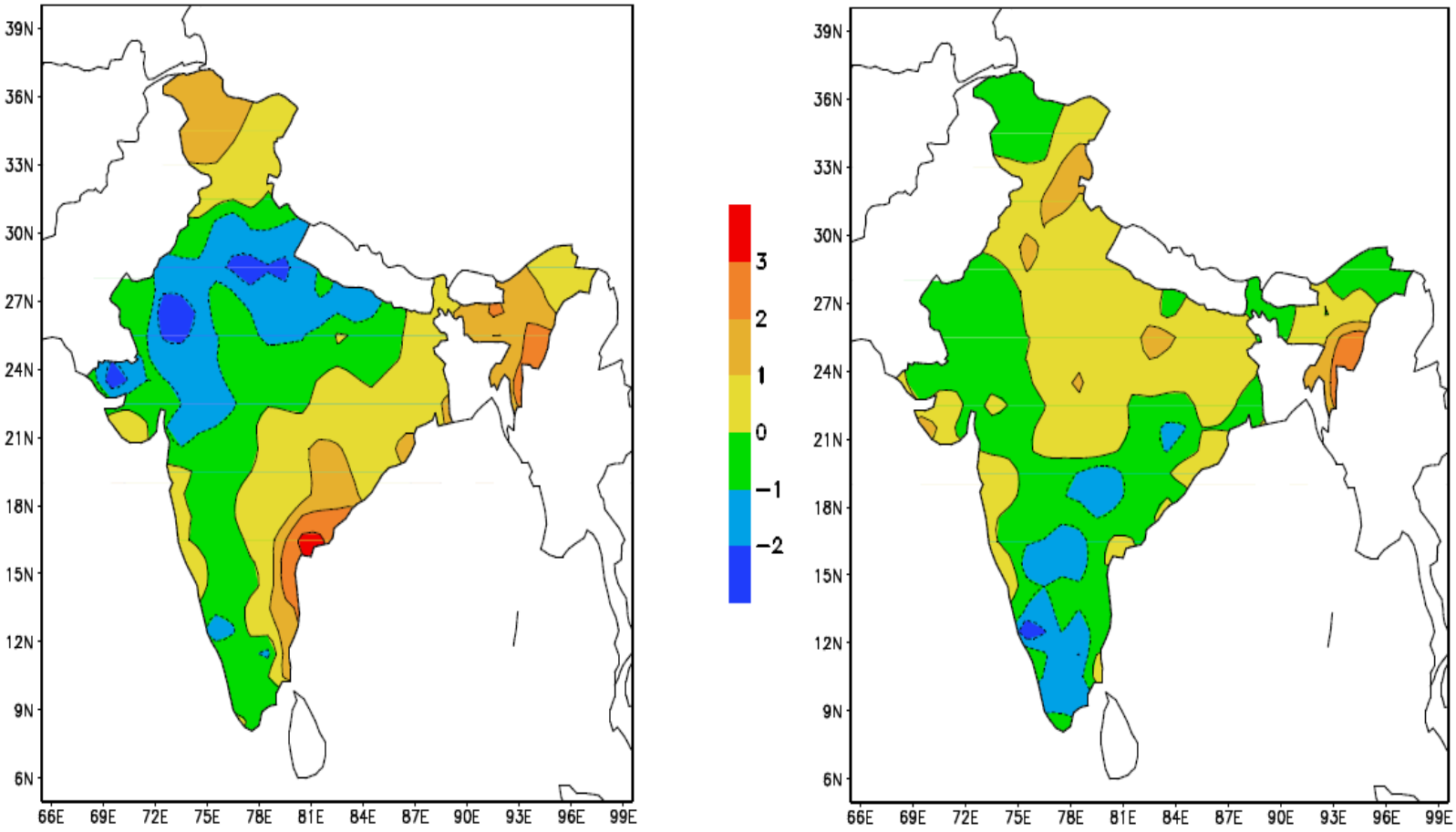


Fig. 8. Sub-division wise Rainfall during Pre-monsoon season 2008.



(a) **(b)**

Fig. 9. Mean Maximum Temperature Anomaly during Pre-monsoon season 2008 (a) May (b) April

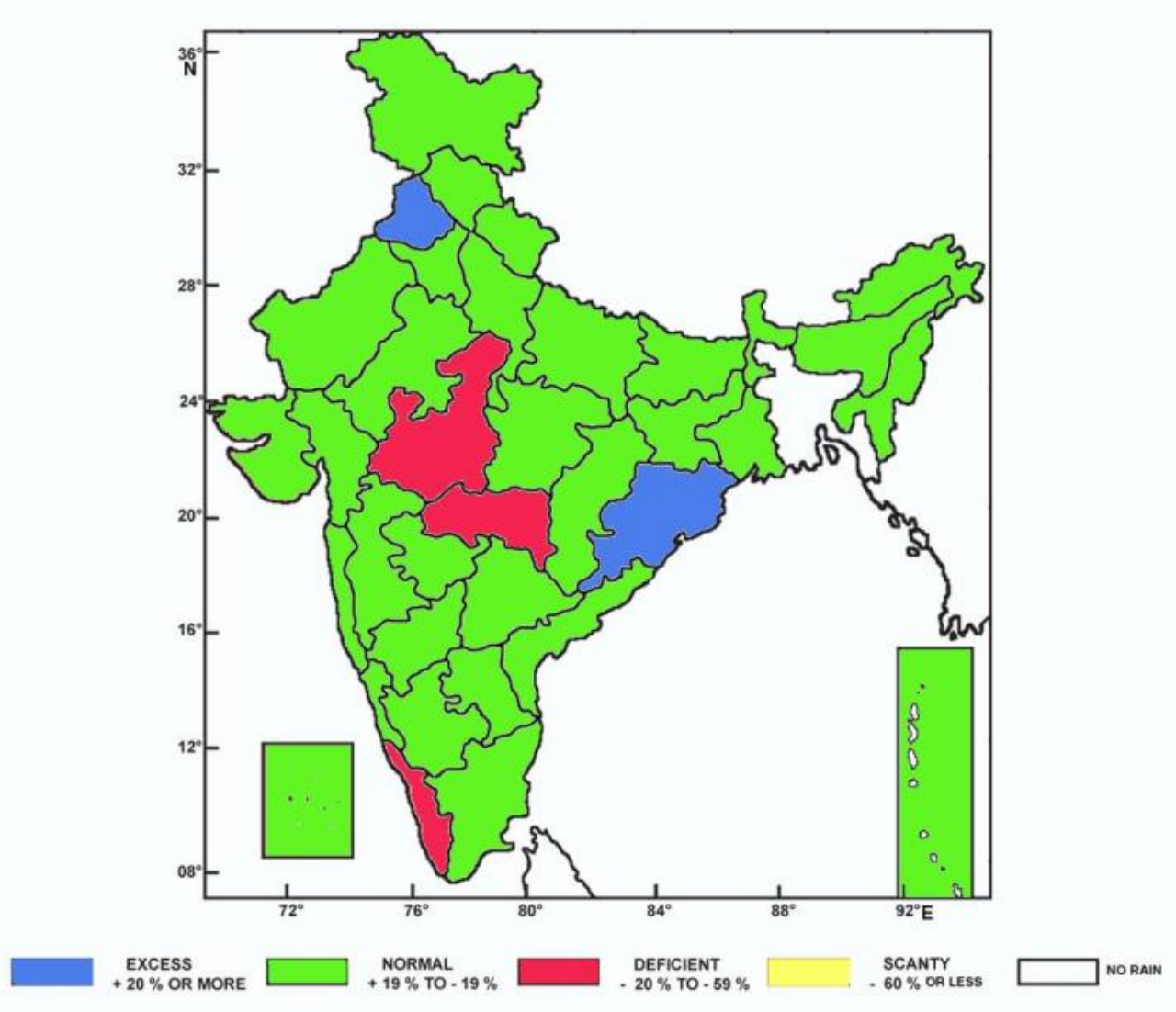


Fig. 10. Sub-division wise Rainfall during Monsoon season 2008.