



**Government of India
Ministry of Earth Sciences
India Meteorological Department**

Press Release

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Annual Climate Summary of India during 2010

Salient features

- Mean annual temperature for the country as a whole during 2010 was **+0.93 °C** above the 1961-1990 average. It was slightly higher than that of the year 2009, thus making the year 2010 as the warmest year on record since 1901.
- Considering different seasons, Pre- Monsoon season (March-May) in 2010 was the warmest since 1901 with mean temperature being **1.8 °C** above normal
- The annual total rainfall for the country as a whole was normal during the year 2010 with actual rainfall of **121.5** cm against the long period average (LPA) of **119.7** cm.
- Seasonal rainfall during monsoon season (June to September) contributes about 75% of total annual rainfall for the country as a whole. Seasonal monsoon rainfall during 2010 was **102%** of its LPA of 89 cm. Out of 597 meteorological districts for which data are available, 29% of the districts (173 districts) received excess rainfall, 40% (240 districts) received normal rainfall, 29% (173 districts) received deficient rainfall and the remaining 2% (11 districts) received scanty rainfall during the season.

- The north Indian Ocean witnessed the formation of **eight** cyclonic disturbances (depression & above) during 2010 which was far below the normal of 13 disturbances. However, five cyclones formed during 2010 which is the first such year after 1998 when six cyclones formed. There was no depression during monsoon season.
- Out of **five** cyclones, **three** cyclones made landfall with atleast cyclonic storm intensity. Out of these three, only **one** (severe cyclonic storm, LAILA, 17-21 May 2010) crossed Indian coast (crossed Andhra Pradesh coast near Bapatla on 20th May evening).
- Death toll due to heavy rains / floods in different parts of the country, during the monsoon season, was more than 500 (mostly from northern and northwestern parts). Heavy rainfall events in November 2010 took a toll of more than 50 people from peninsular parts (AP, TN and Karnataka) of the country.
- Northeastern states, sub-Himalayan West Bengal and Bihar experienced enhanced thunderstorm activity during pre-monsoon season, 2010.
- Abnormally warm conditions (heat wave) prevailed over major parts of the country during March and April months. These heat wave conditions claimed more than 300 lives.
- Severe cold wave conditions prevailed over northern plains in January and during first fortnight of February. Maximum temperature over a number of stations over the northern plains was 5 to 10^o C below normal on many occasions during January. Cold wave conditions claimed more than 600 lives.
- A Tornado like situation with strong winds estimated to be more than 100 kmph raged havoc in West Bengal and Bihar on 13 April, claiming more than 120 lives. More than 80000 houses were destroyed.
- A cloud burst in early hours of 6 August in Leh (J&K) claimed more than 150 lives and more than 500 people were missing.

Annual Climate Summary of India during 2010

Characteristic features of various weather and climatic conditions over India during 2010 are described below.

Temperature :

The characteristics of temperatures during year 2010, different seasons and months are discussed below.

- **Annual Mean Temperature**

In 2010, annual mean temperature averaged over the country as a whole was +0.93 °C above the 1961-1990 average [Fig. 1]. The year 2010 was the warmest year on record since 1901. The other warmer years on record in order are 2009 (0.92), 2002(0.71), 2006(0.6), 2003(0.560), 2007(0.553), 2004(0.515), 1998(0.514), 1941(0.448), 1999 (0.445), 1958(0.435), 2001(0.429) and 1987(0.413). Details are given in Table 1.

Table 1: Temperature ranking 2001-2010

RANKING (2001-2010)	YEAR	TEMPERATURE (°C)	ANOMALY (°C)
WARMEST	2010	25.8023	0.9319
2	2009	25.7876	0.9172
3	2002	25.7366	0.7084
4	2006	25.5024	0.6016
5	2003	25.4720	0.5600
6	2007	25.4430	0.5528
7	2004	25.4232	0.5143
8	2001	25.3848	0.4292
9	2005	25.2800	0.4096
COLDEST	2008	25.2562	0.3857

Considering spatial pattern, mean annual temperature were generally above normal throughout the country. These anomalies (Departure from normal) were more than **1.0 °C** over most parts of the central and northern India (Fig.2).

The analysis of both maximum and minimum temperatures (Fig.3) indicates that both these temperatures contributed to the rise in mean temperature over India.

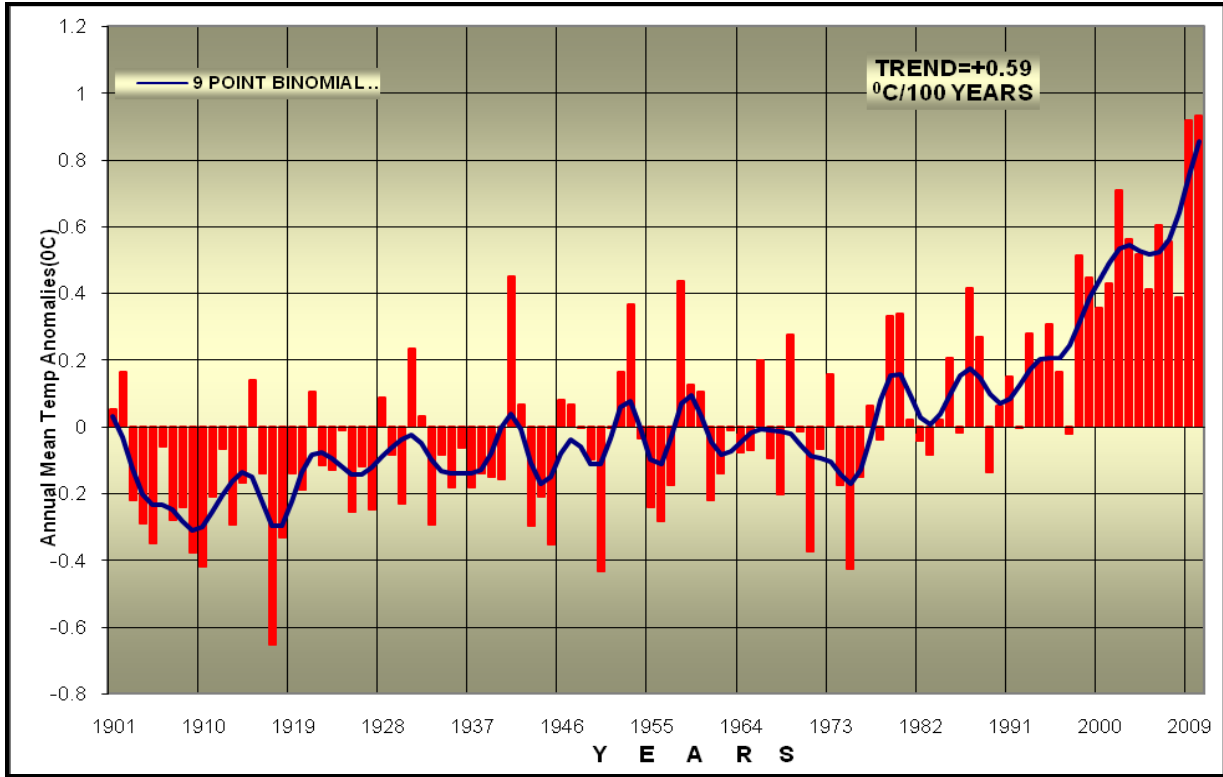


Fig.1. Annual mean temperature anomaly(Departure from normal)

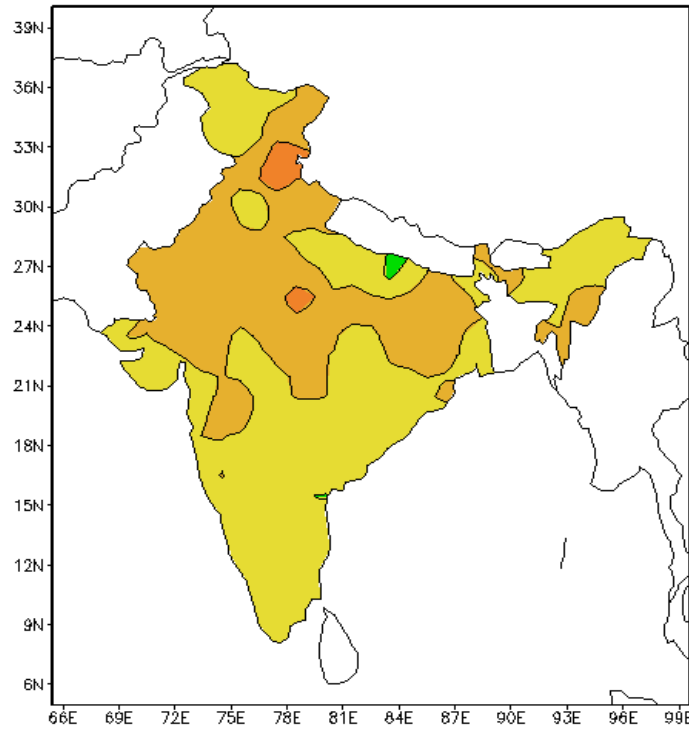
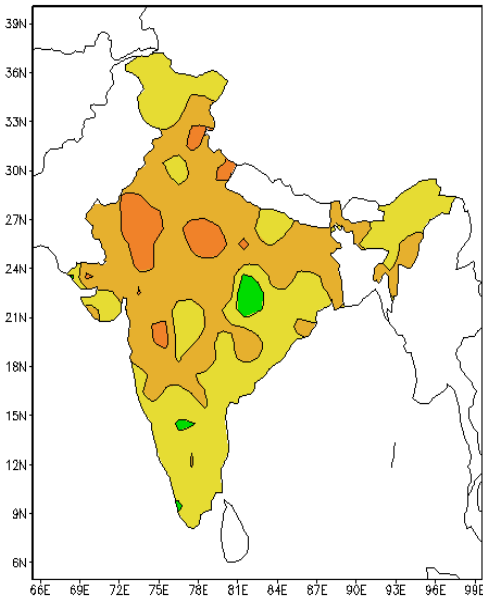


Fig.2: Spatial pattern of annual mean temperature anomaly (Departure from normal) over India during 2010

(a) Maximum temperature



(b) Minimum temperature

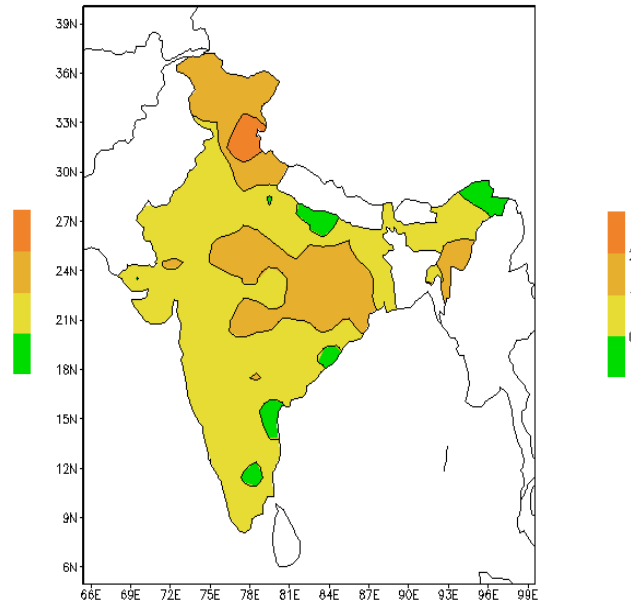
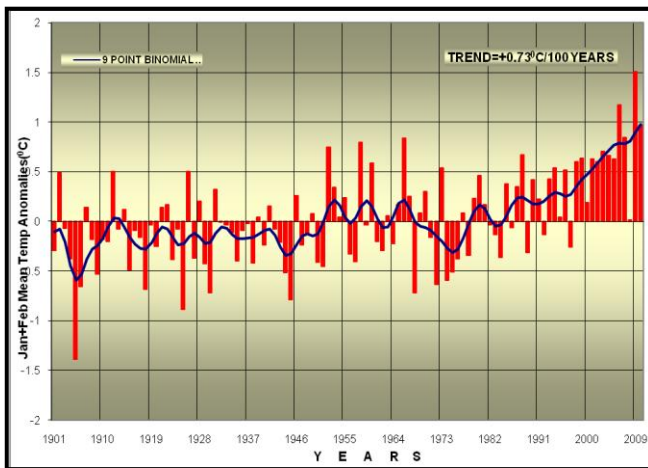


Fig.3: Annual mean (a) maximum and (b) minimum temperature anomalies (Departure from normal) over India during 2010

- **Seasonal Mean Temperature**

Trends in mean temperature for different seasons viz. winter (Jan to Feb), pre-monsoon (Mar to May), monsoon (June to Sept) and post-monsoon (Oct to Dec) seasons are shown in following Fig.4). **Pre- Monsoon season in 2010 was the warmest** since 1901 with mean temperature being 1.8°C above normal.

(a) Winter



(b) Pre-monsoon

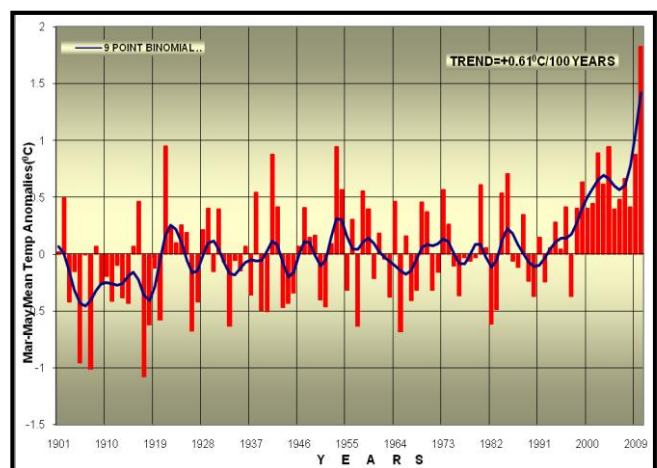
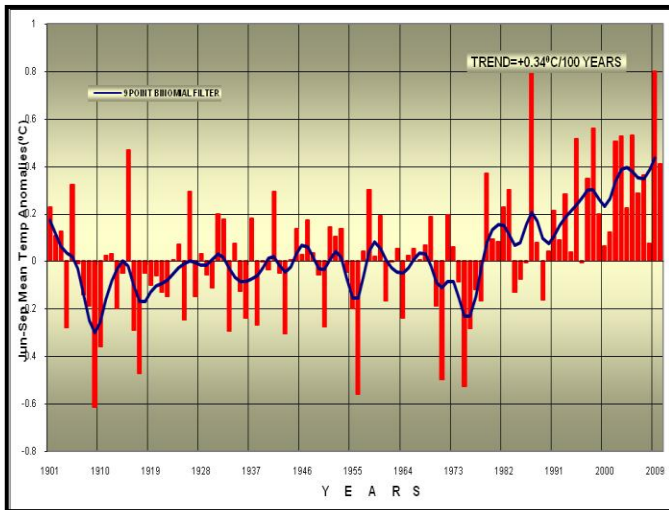


Fig.4 (a-b). Mean temperature anomaly (Departure from normal) of India during (a) winter and (b) pre-monsoon seasons

(c) Monsoon



(d) Post-monsoon

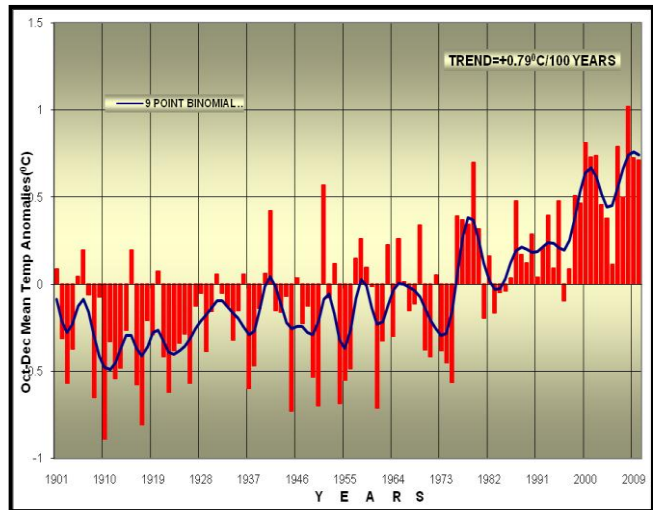


Fig.4 (c-d). Mean temperature anomaly (Departure from normal) of India during (c) monsoon and (d) post-monsoon seasons

- **Monthly Mean Temperature**

Mean monthly temperature over the country as a whole was the highest since 1901 for March (2.27°C), April (2.02°C) and November (1.17°C) 2010 and the second highest for May 2010 (1.17°C). Abnormal warm conditions (minimum temperature exceeding the normal by 5°C on many days) prevailed over the peninsular/ central parts during November making it record warmest since 1901.

Both maximum and minimum temperatures contributed for record warming of March, April and May months, while above normal minimum temperatures were apparently responsible for record high temperature in November.

- **Decadal variation of temperature**

The mean temperature during different decades over the of 1901-2010 are shown in Table 2. It is found that the decade 2001-2010 has been the warmest decade with a temperature anomaly of 0.4°C .

Table 2: Decadal variation of temperature

Decade	Mean Temperature ($^{\circ}\text{C}$)	Anomaly with respect to 1961-1990 ($^{\circ}\text{C}$)
1901-1910	25.1	-0.2
1911-1920	25.2	-0.2
1921-1930	25.3	-0.1
1931-1940	25.2	-0.2
1941-1950	25.5	-0.1
1951-1960	25.7	0.0

1961-1970	25.7	-0.1
1971-1980	25.7	0.0
1981-1990	25.9	0.1
1991-2000	26.1	0.2
2001-2010	26.3	0.4

Rainfall features

The annual total rainfall for the country as a whole was normal during the year 2010 with actual rainfall of 121.5 cm against the long period average (LPA) of 119.7 cm (Table 1). However, there was large spatio-temporal variation of rainfall. While the rainfall for the country as a whole was normal during pre-monsoon season and post-monsoon seasons, it was deficient during winter and excess during post-monsoon season respectively. The rainfall during 2010 was excess/normal over most part of the country except Punjab, east Madhya Pradesh, east Uttar Pradesh, Bihar, Jharkhand and Gangetic West Bengal where it was deficient.

(Fig.5) Deficient rainfall over these sub-divisions except Punjab was mainly due to deficient rainfall during monsoon season and that over Punjab was mainly due to scanty and deficient rainfall during winter and post monsoon season respectively. Details of rainfall distribution during different months and seasons are given in Table.3.

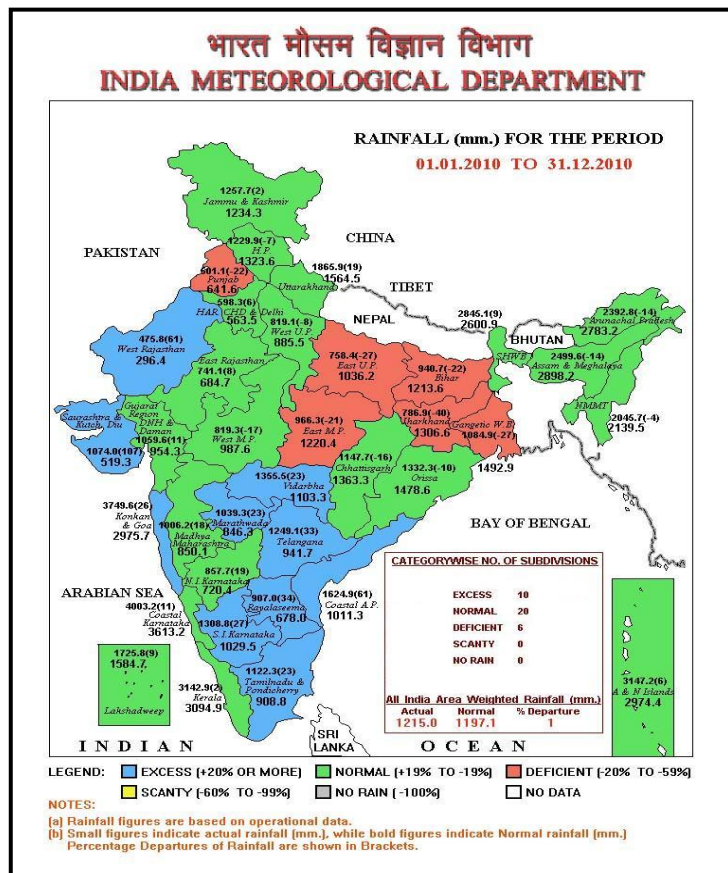


Fig.5. Annual total rainfall over India during 2010

Table 3. All India rainfall (mm) during 2010

Period	Actual	Normal	% Departure
January	7.5	20.9	-64
February	17.0	23.0	-26
March	14.0	31.4	-56
April	39.0	38.8	00
May	73.8	63.5	16
June	138.0	163.5	-16
July	300.5	292.3	03
August	274.7	261.9	05
September	197.4	175.5	12
October	69.0	78.9	-13
November	58.0	29.8	95
December	22.4	17.8	26
Winter season	24.5	43.9	-44
Pre-monsoon season	126.7	133.7	-05
Monsoon season	910.6	893.2	02
Post-monsoon season	153.2	126.3	21
Annual	1215.0	1197.1	01

- **Winter Season (Jan-Feb 2010):**

The rainfall during winter season was deficient (44% below the LPA) for the country as a whole. Considering different meteorological sub-divisions, the seasonal rainfall was excess/normal over Jammu & Kashmir, Karnataka, Maharashtra, Goa, Andhra Pradesh and Andaman & Nicobar Islands. It was deficient/scanty over the remaining parts of the country. (Fig.6)

- **Pre-Monsoon Seasons (March-May 2010):**

The rainfall during pre-monsoon season was near normal over the country as a whole. However, considering meteorological subdivisions, the seasonal rainfall was excess/normal over Tamil Nadu, Puducherry, Andhra Pradesh, south Karnataka, Orissa, West Bengal, northeastern states, Bihar and Jammu & Kashmir. It was deficient/scanty over remaining parts of the country (Fig.6).

- **Monsoon Season (June-September 2010):**

The 2010 southwest monsoon season rainfall over the country as a whole was normal. Rainfall activity for the country as whole on even on daily scale was generally normal to above normal on most of the days during the season, except during the last 10 days of June, middle of July, first week of August and last week of September.

Onset of southwest monsoon took place over Kerala on 31 May, a day ahead of the normal date (1 June) and the monsoon regularly advanced westwards and

northwards up to 18 June covering Peninsular, northeastern / eastern parts of the country. Subsequently, there was a prolonged hiatus of about two weeks and further progress of the monsoon started only on 1 July. It regularly and rapidly, covered the remaining eastern and entire northern/northwestern parts of the country and thus the entire country by 6th July, about 9 days ahead of its normal date (15 July).

For the country as a whole, seasonal rainfall at the end of the southwest monsoon season (June to September) was **102%** of its LPA.

During the season, out of 36 meteorological subdivisions, 14 received excess rainfall, 17 received normal rainfall and remaining 5 subdivisions received deficient rainfall (Fig 6)). Out of 597 meteorological districts for which data are available, 29% of the districts (173 districts) received excess rainfall, 40% (240 districts) received normal rainfall, 29% (173 districts) received deficient rainfall and the remaining 2% (11 districts) received scanty rainfall during the season.

The annual monsoon rainfall during 1901-2010 are shown in Fig. 7 There is no significant trend in monsoon rainfall over the years. However, there has been three all India drought years during the recent decade, viz., 2002, 2004 and 2009. All other years during the decade (2001-2010) has been normal rainfall years.

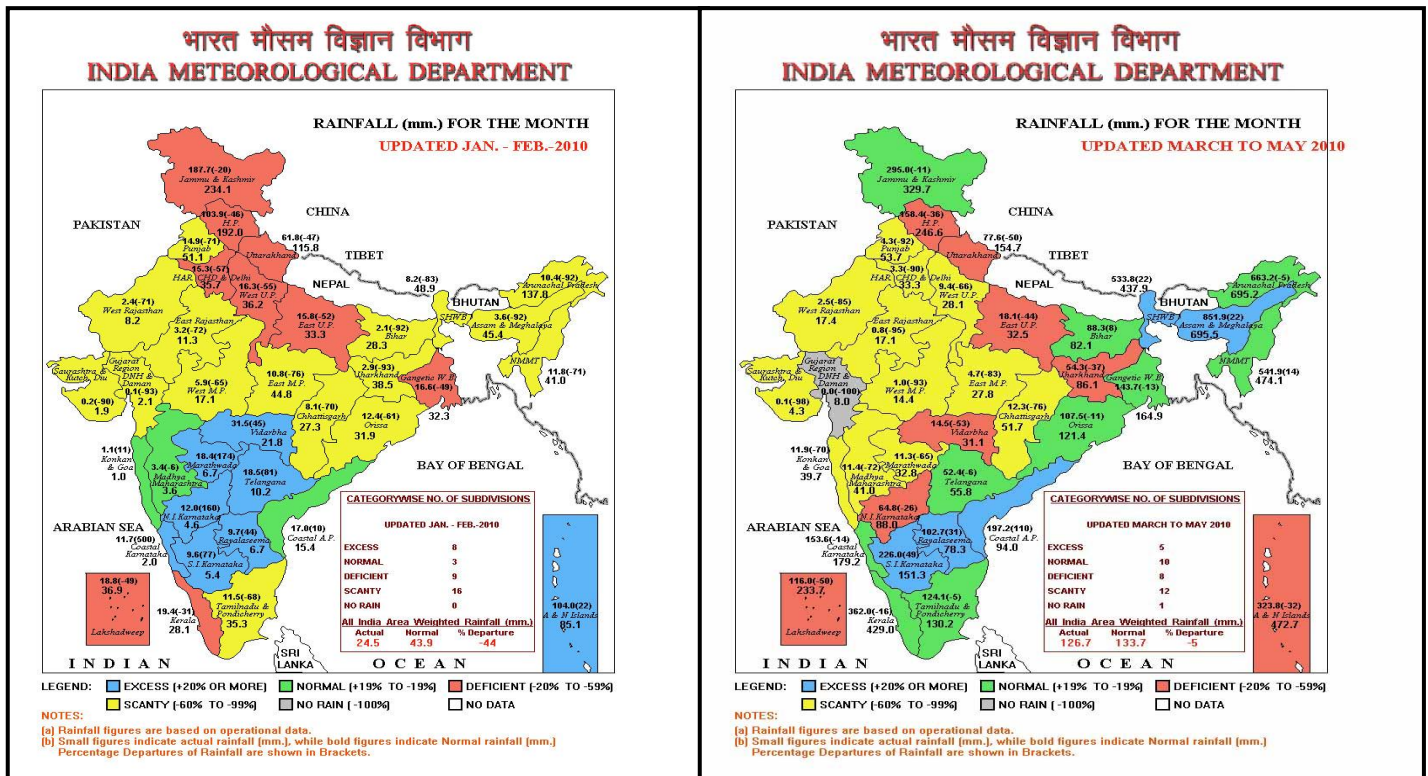


Fig.6 (a-b). Sub-divisional rainfall over India during winter and pre-monsoon, seasons of 2010

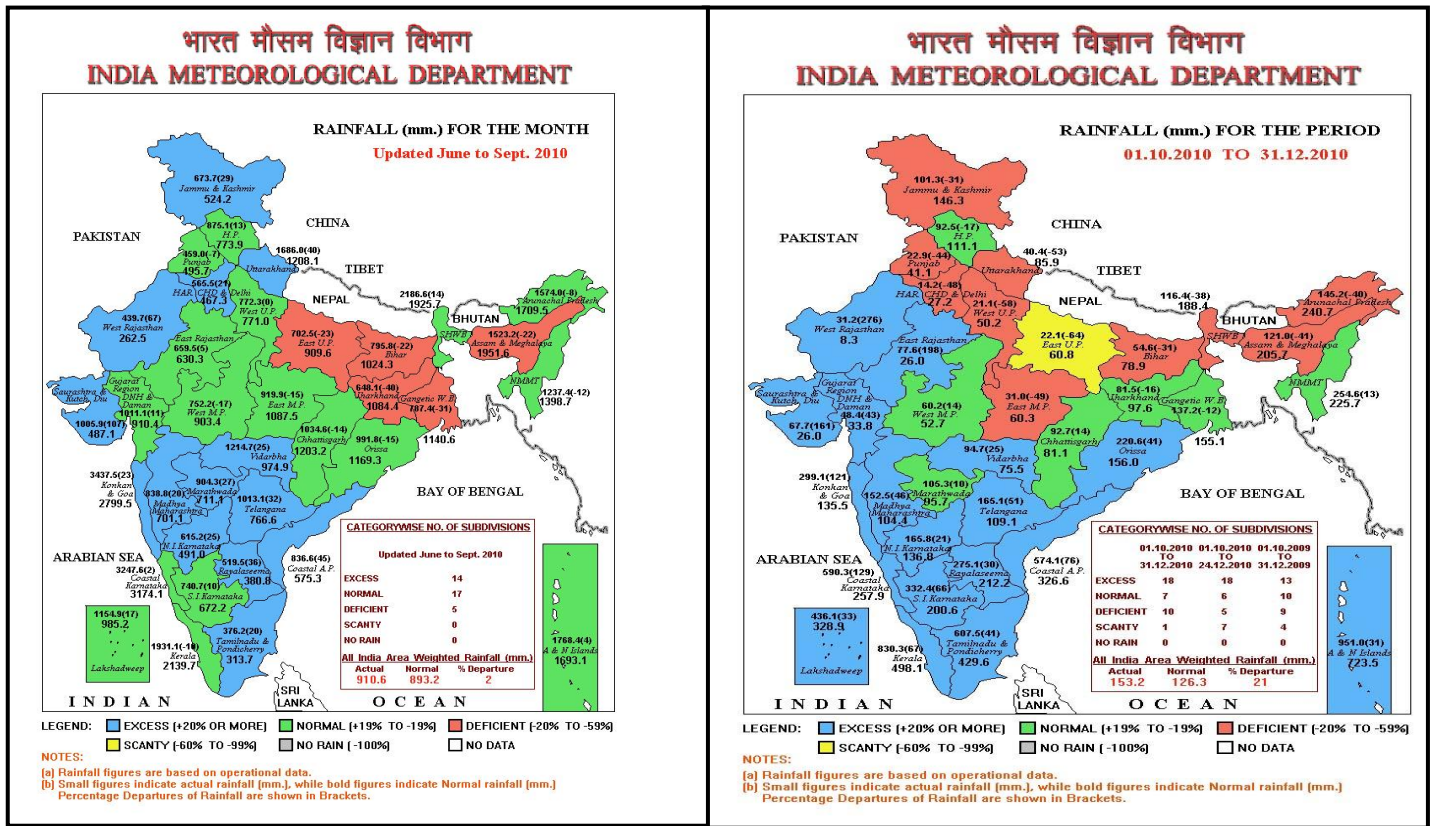


Fig.6 (c-d). Sub-divisional rainfall over India during monsoon and post-monsoon seasons of 2010

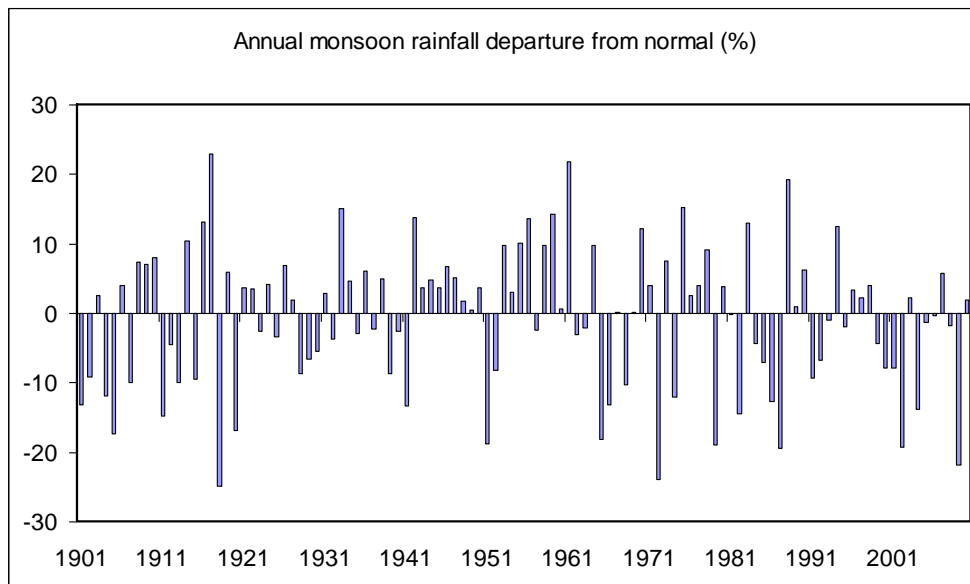


Fig.7. Annual monsoon rainfall over India during 1901-2010

- **Post-Monsoon Season**

Rainfall for country as a whole was **121% of** the normal value (Table 1). All five sub-divisions viz: Tamil Nadu, Rayalaseema, coastal Andhra Pradesh, south interior Karnataka and Kerala (core regions receiving northeast monsoon rainfall) received excess rainfall (Fig.6). Seasonal rainfall over these sub-divisions was 155% of the normal value. The remaining parts of south India as well as west and east India also received excess to normal rainfall.

La Nina conditions during 2010

The El Niño conditions that were originated since June, 2009 peaked in December 2009 and then started to weaken to reach ENSO-neutral conditions in May 2010 (Fig.8). This continued till mid June when weak La Nina conditions emerged. Evolution of SST anomalies in the four NINO regions since January, 2010 is shown in the Fig.1. The SST anomalies in the NINO 3.4 region continuously decreased from January and crossed the threshold value of -0.5 Degree C during later part of the month of June. For June 2010, the SSTs in the NINO3.4 region were slightly below average (-0.4^o C). During the subsequent months SST anomaly decreased continuously, La Niña conditions prevailed with negative SST anomaly in the NINO3.4 region during monsoon season. In the NINO 1+2 and NINO 3 regions, SST anomalies were negative since middle of May. Moderate to strong La Niña conditions prevailed since mid-August 2010. For November, the SST anomaly in the NINO3.4 region was -1.45^o C, indicative of moderate to strong La Niña conditions, and for the September-November season the anomaly was -1.53^oC.

Latest observations and climate model forecasts indicate that for the December to February 2011 season, there is an approximately 98% probability for continuing La Niña conditions, and a 2% probability for returning to neutral ENSO conditions. Probabilities for La Niña conditions continue at 94% or more through the January-February-March season of 2011, and do not drop to below 50% until the April-June season.

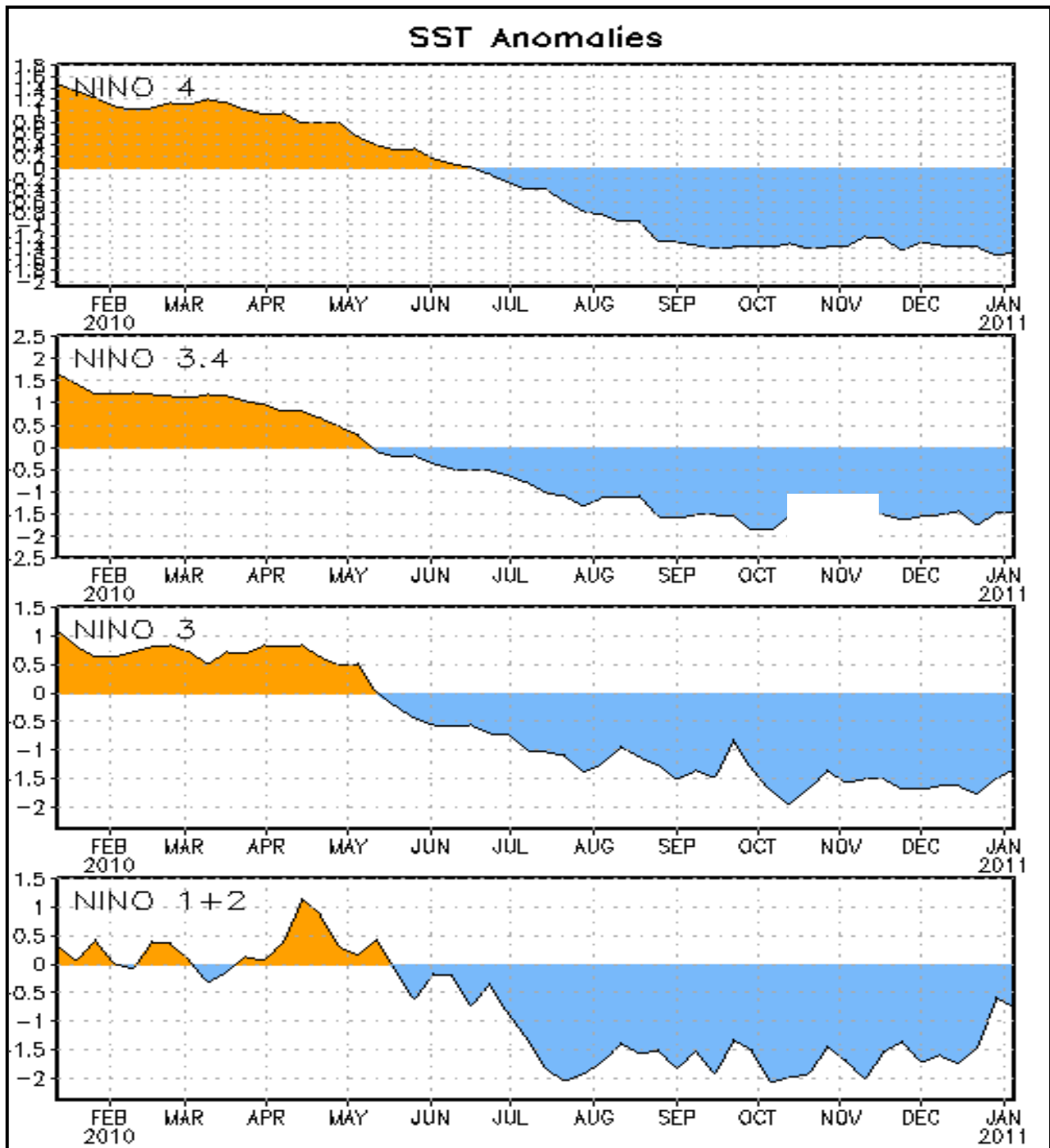


Fig.8. Sea surface Temperature (SST) anomaly over different NINO regions indicating La Niña conditions during monsoon and post-monsoon seasons, 2010

High Impact Weather Events

Cyclonic disturbances during 2010

- The north Indian Ocean witnessed the formation of eight cyclonic disturbances during 2010 which was far below the normal of 13 disturbances. However, five cyclones formed during 2010 which is the first such year after 1998 when six cyclones formed.
- Out of eight disturbances six cyclonic disturbances formed over the Bay of Bengal and two over the Arabian Sea.
- Out of the six cyclonic disturbances over the Bay of Bengal, one intensified upto the stage of very severe cyclonic storm (GIRI), two upto the stage of severe cyclonic storm (LAILA & JAL), one upto the stage of deep depression and rest two upto the stage of deoression. Out of two cyclonic disturbances formed over the Arabian Sea, one intensified upto the stage of very severe cyclonic storm (PHET) and the other (BANDU) upto the stage of cyclonic storm.
- Tracks of the cyclonic disturbances formed over the north Indian Ocean during the period is shown in Fig.9.
- There were no cyclonic disturbances formed over the north Indian Ocean during monsoon season. Comparing with past records (1891-2009), there was only one such year viz. 2002. On an average, 7 cyclonic disturbances formed over the north Indian Ocean during the monsoon season. While the year 2002 was an all India drought year, the year 2010 was a normal rainfall year. It was mainly because of the fact that the absence of cyclonic disturbances was compensated by the number of low pressure areas over the region. There were 13 low pressure areas during the season against the normal of 6. Considering low pressure systems including lows and cyclonic disturbances (depression and above), about 13.5 such systems developed normally during monsoon season.
- Out of five cyclones, three cyclones made landfall with atleast cyclonic storm intensity. Out of these three, only one (severe cyclonic storm, LAILA, 17-21 May 2010) crossed Indian coast (crossed Andhra Pradesh coast near Bapatla on 20th May evening). The typical imagery of this cyclone is shown in Fig.10. It caused death of 6 person and loss of property. It was the first ever severe cyclone to cross Andhra Pradesh coast after 1990 in the month of May. A very severe cyclone crossed Andhra Pradesh coast near the same area during May, 1990.
- The cyclone Phet over the Arabian Sea had the rarest of the rare track with two landfall points over Oman and Pakistan and longest track in recent years.
- Cyclonic Storm, 'BANDU' over the Arabian Sea (19-23 May 2010) moved west wards and dissipated over Gulf of Aden.
- Very Severe Cyclonic Storm, 'GIRI' over the Bay of Bengal (20-23 October, 2010) crossed Myanmar coast near Kyaukpyu on 22nd October evening. No severe cyclone crossed Arakan coast prior to cyclone, GIRI during the month of October, as evident from the data of 1891-2009.
- Severe Cyclonic Storm, 'JAL' (04-08 November, 2010) weakened before the landfall and crossed north Tamil Nadu and Andhra Pradesh coast to the north of Chennai on 7th November evening, as a deep depression. The convective clouds

were sheared to the west to a large extent on the date of landfall leading to more rainfall over interior parts than the coastal regions and caused flood.

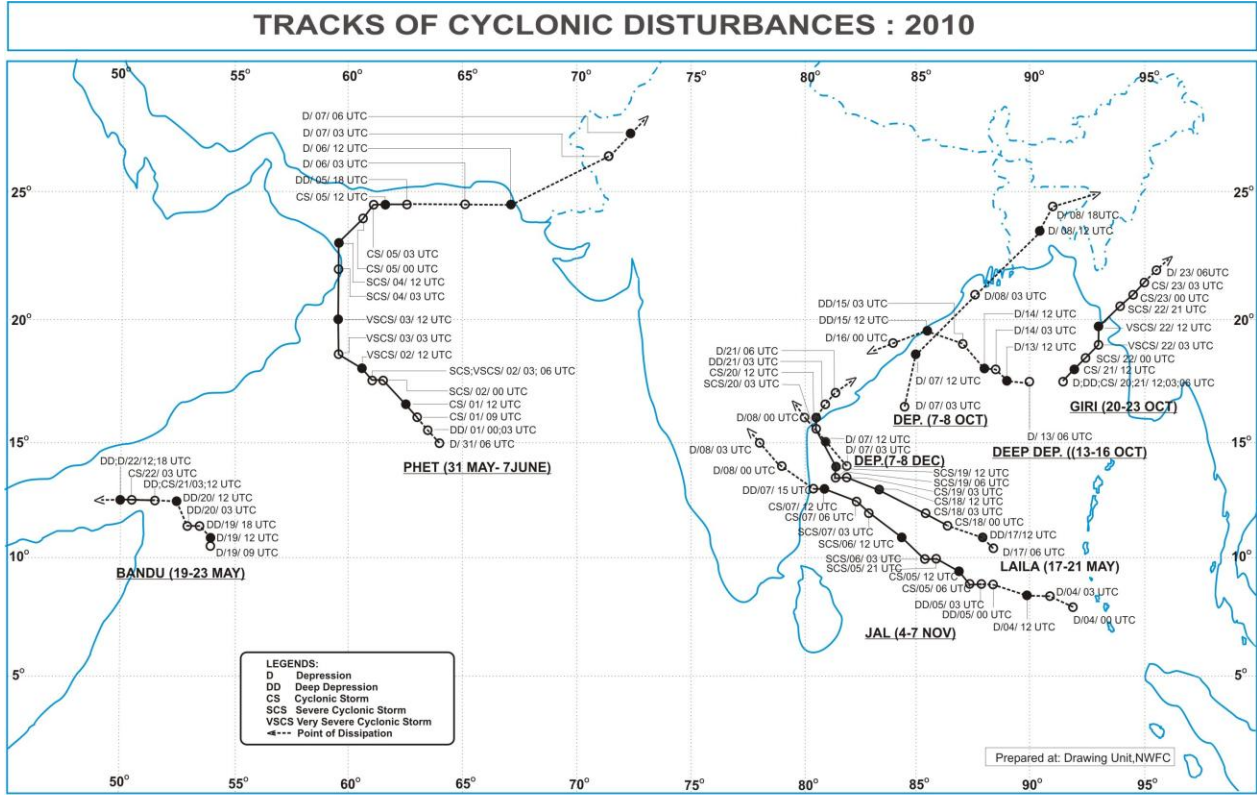


Fig. 9. Tracks of cyclonic disturbances during 2010

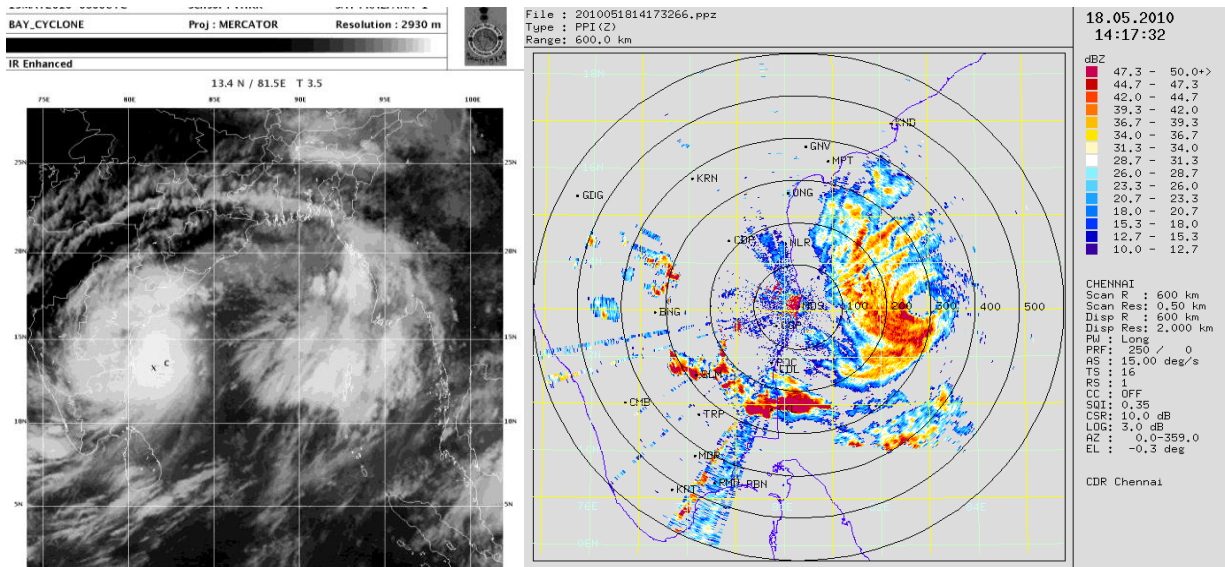


Fig. 10. Typical satellite and Radar imageries of cyclone, LAILA Heavy rainfall

- Death toll due to heavy rains / floods in different parts of the country, during the southwest monsoon season, was more than 500 (mostly from northern and northwestern parts).
- Heavy rainfall events in November 2010 took a toll of more than 50 people from peninsular parts (AP, TN and Karnataka) of the country.
- A few stations reported record rainfall in 24 hrs during monsoon and post-monsoon seasons which are given in the Table 4 and Table 5 respectively.

Table 4. Record rainfall (in 24 hrs.) during the monsoon season, 2010

S. No.	Station	Rainfall during past 24 hrs. (mm)	Date (June 10)	Previous record (mm)	Date of record	Year of record
1	N. Lakhimpur	207.8	16	183	22	1990
2	Osmanabad	111.2	23	68.2	3	2000
3	Thanjavur	61.0	11	55	12	1996
4	Cial Cochi	160.6	13	93.9	6	2004
(July 10)						
1	Phoolbagh	146.2	21	123.6	11	2003
2	Damoh	253.6	26	225.1	18	1973
3	Okha	330.5	27	283.3	10	1973
4	Osmanabad	110	3	108.6	24	1979
5	Anantpur	123	11	114.8	17	1989
6	Kurnool	102	6	101.7	25	1983
7	Nandyal	143.2	11	116	16	1989
8	Dharmapuri	117	9	91.6	12	1989
9	Mandya	46.4	12	46.1	12	1978
(Aug 10)						
1	Okha	226.5	3	119.8	11	1981
2	Bhira	380	30	350	23	1997
3	Osmanabad	149.8	22	85	21	2009
4	Narsapur	64.6	13	63.8	14	2001
5	Arogyavaram	111	21	90	9	1970
(Sept 10)						
1	Ranchi AP	205.8	12	168.4	28	1963
2	Pant Nagar	117.2	7	105	10	1967
3	Bharatpur	107	4	91.8	17	1990
4	Gwalior	159.8	20	157.8	4	1995
5	Dhar	170.8	8	151	21	1973
6	Okha	91	10	74.5	12	1997
7	Vijaywada AP	132.4	4	127.6	19	1988
8	Narsapur	115.7	13	88.9	24	1997
9	Mangalore AP	150.2	24	125.5	6	1902
10	Panambur	125.2	24	113.6	26	1998
11	Belgaum (AP)	150	24	100.4	20	1981
12	Cochi AP	183.5	24	128	28	2009
13	Cial Cochi	108	24	77.4	18	2009

Table 5. Record rainfall (in 24 hrs.) during the post-monsoon season, 2010

S.No	Station	Rf mm. (New Record)	Date (Oct 10)	Previous Record	Date	Year
1	Pune	181.3	5	149.1	24	1892
2	Vijaywada ap	108.2	24	98.1	18	1980
3	Narsapur	124.6	31	101.3	30	1997
(Nov. 10)						
1	Etawah	10.5	18	7.7	9	1982
2	Barmer	54.0	12	37.3	21	1976
3	Ajmer	46.0	24	42.4	29	1958
4	Jaipur ap	47.2	24	22.9	3	1981
5	Gwalior	24.3	25	15.1	13	2009
6	Datia	46.6	18	46.0	28	1979
7	Khandwa	101.0	18	84.8	10	1936
8	Raikot	41.8	17	30.0	8	1982
9	Rajnandgaon	24.2	12	18.2	9	1998
10	Visakhapatnam	180.2	1	177.0	26	1992
11	Tun i	194.3	1	45.6	16	1998
12	Karwar	207.4	9	141.0	23	1948
(Dec. 10)						
1	Churu	25.1	29	19	23	1967
2	Raipur	64.1	9	52.1	26	1909
3	Mana ap	29.9	9	26.8	14	1997
4	Kakinada	116.4	8	102.4	13	1969
5	Vijaywada ap	49.6	7	23.2	13	1988
6	Visakhapatnam	109.7	8	12.8	28	1989
7	Bapatla	104.2	7	83.8	16	2003
8	Narsapur	100.3	7	70.5	16	2003
9	Panambur	52.8	11	50.4	14	1998

Thunder Storm and Tornado during 2010

- Northeastern states, sub-Himalayan West Bengal and Bihar experienced enhanced thunderstorm activity during pre-monsoon season, 2010.

Heat Wave

- Abnormally warm conditions (heat wave) prevailed over major parts of the country during pre monsoon months. Temperature over northwestern/ Northern and central parts of the country was 3 to 5° C above normal in the second fortnight of March and in April. During May, mean temperature over northwestern/ Northern and central parts of the country was 4 to 6° C above normal. These heat wave conditions claimed more than 300 lives. Significant heat wave spells are shown in Fig.11

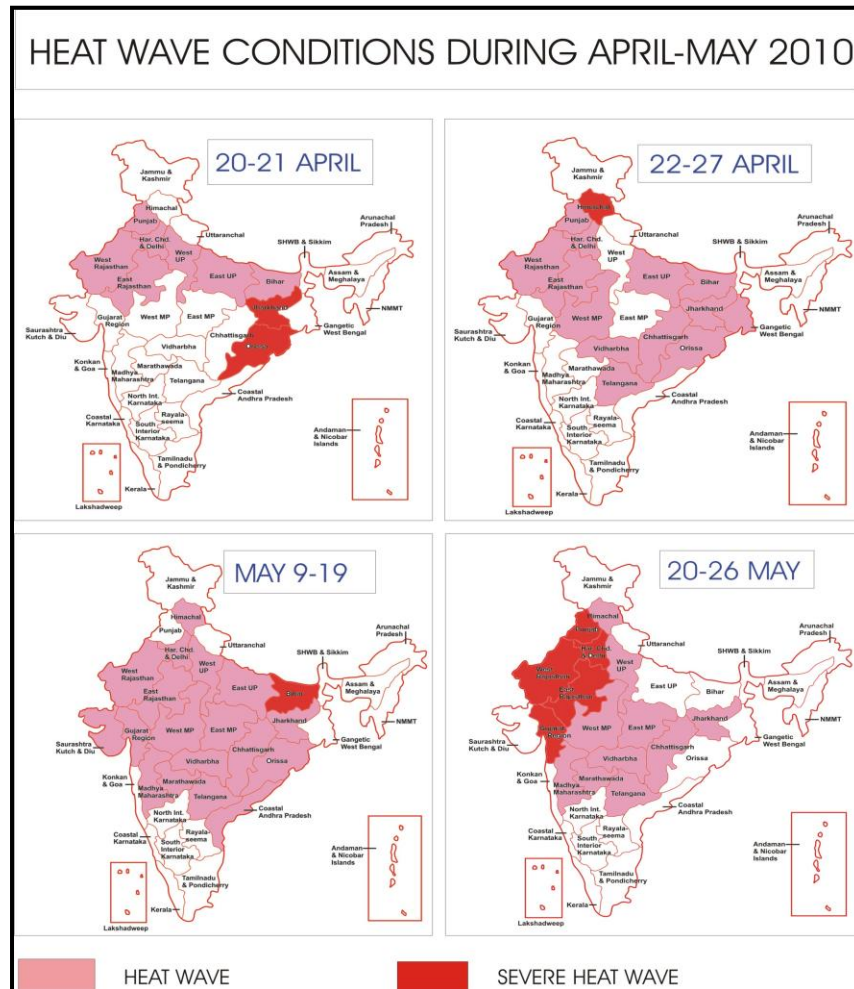


Fig.11. Significant heat wave conditions over India during April and May 2010

Cold Wave

- Severe cold wave conditions prevailed over northern plains in January and during first fortnight of February. Maximum temperature over a number of stations over the northern plains was 5 to 10° C below normal on many occasions during January. Cold wave conditions claimed more than 600 lives.
- Significant cold wave spells during January 2010 are shown in Fig.12

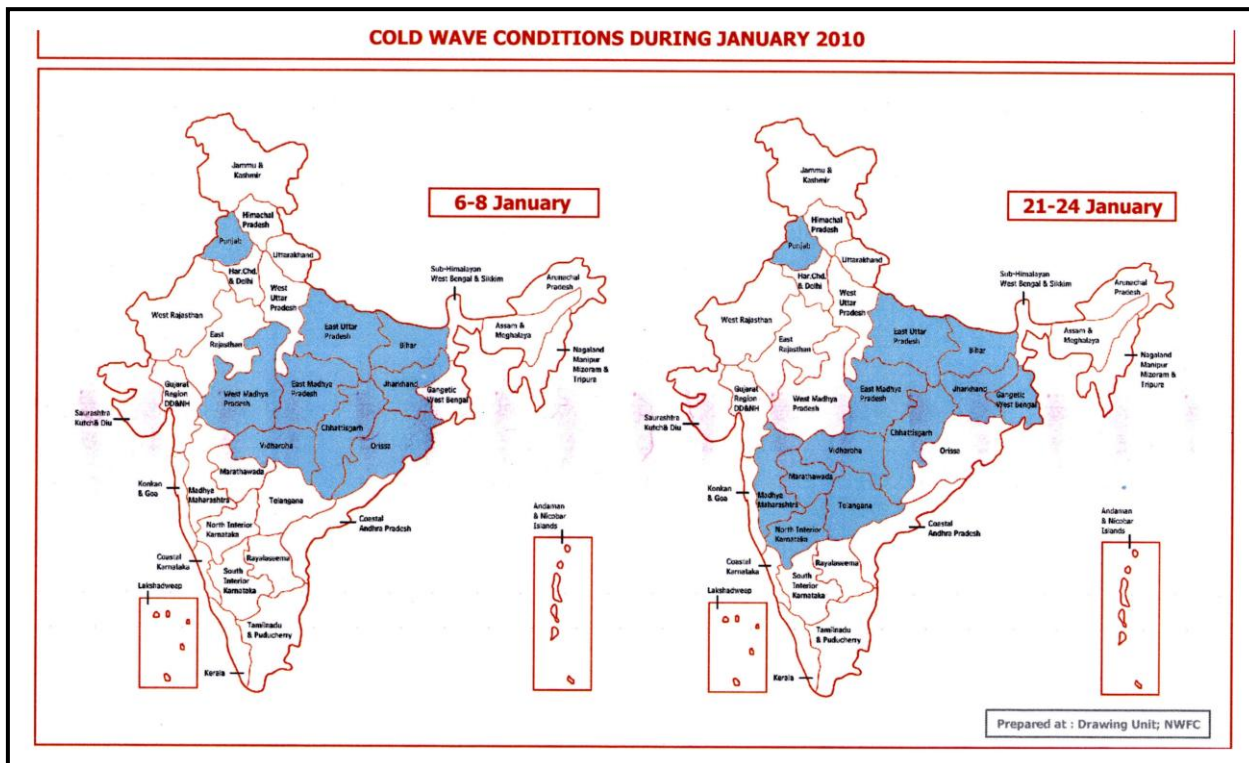


Fig.12. Significant cold wave spells during January 2010

Other high impact weather events during 2010

- An **avalanche** in the second week of February in Jammu Kashmir (northern parts of India) claimed lives of 17 soldiers.
- A **cloud burst** in early hours of 6 August in Leh (J&K) claimed more than 150 lives and more than 500 people were missing.
- A massive **landslide** due to heavy rainfall in Bageshwar (Uttarakhand, Northern India) on August 18 claimed lives of 18 school children.
