Heat wave vulnerable areas and early warning system of IMD

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Heat Wave/Warm Night Definition in India

Heat wave considered when actual max. temp. ≥ 40°C for plains, ≥ 37°C for coastal stations and ≥ 30°C for Hilly regions

a. Based on Departure from Normal

Heat Wave: Departure from normal is 4.5°C to 6.4°C

Severe Heat Wave: Departure from normal is >6.4°C or more

b. Based on Actual Maximum Temperature

Heat Wave: When actual maximum temperature ≥ 45°C

Severe Heat Wave: When actual maximum temperature ≥47°C

c. Criteria for describing *Heat Wave for coastal stations*

When maximum temperature departure is 4.5°C or more from normal,

Warm Night: It should be considered only when max. temp. ≥ 40°C. It is defined based on departures of minimum temperatures and is as follows:

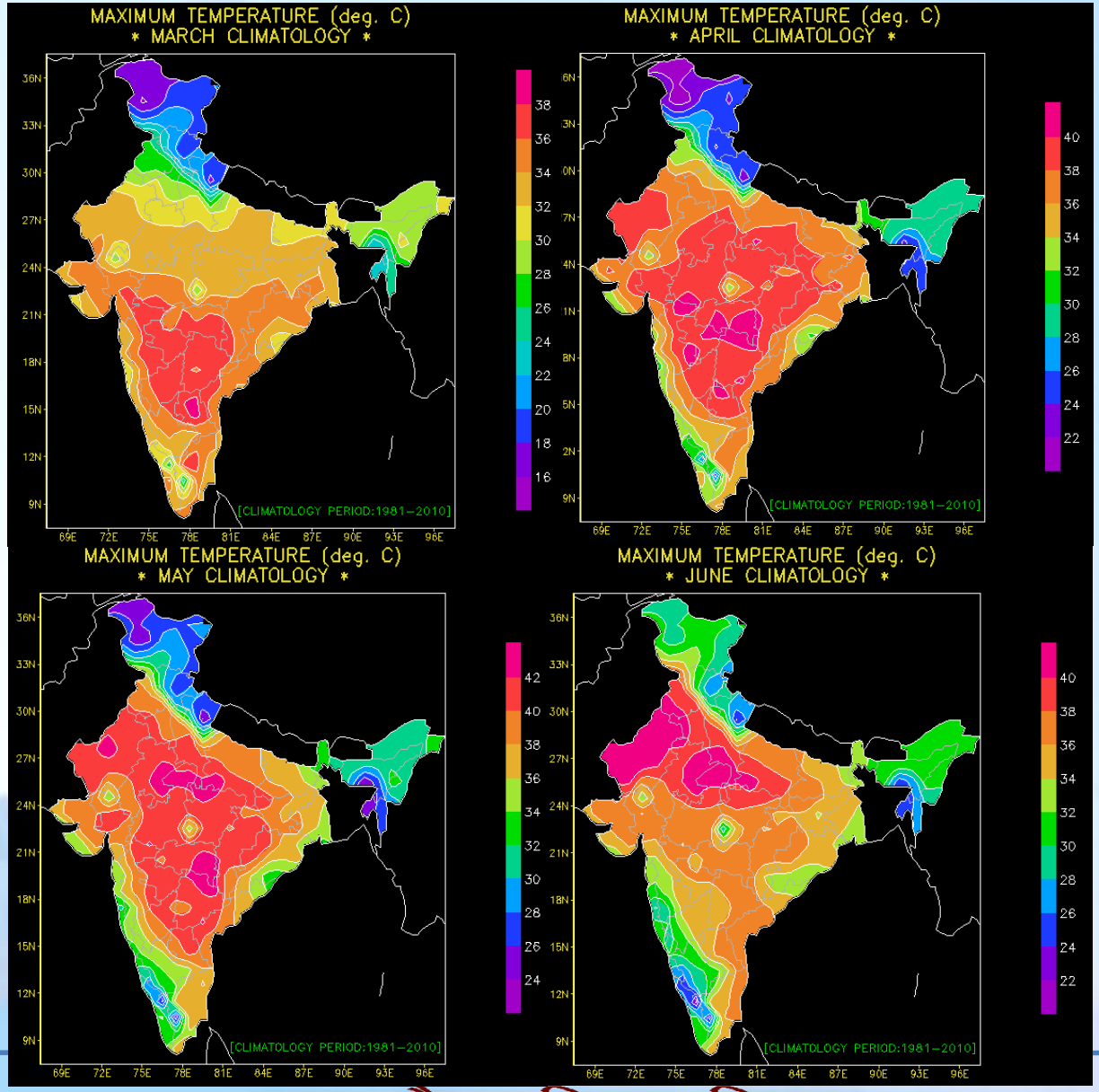
Warm Night: Departure from normal is 4.5°C to 6.4°C

Very Warm Night: Departure from normal is >6.4°C or more

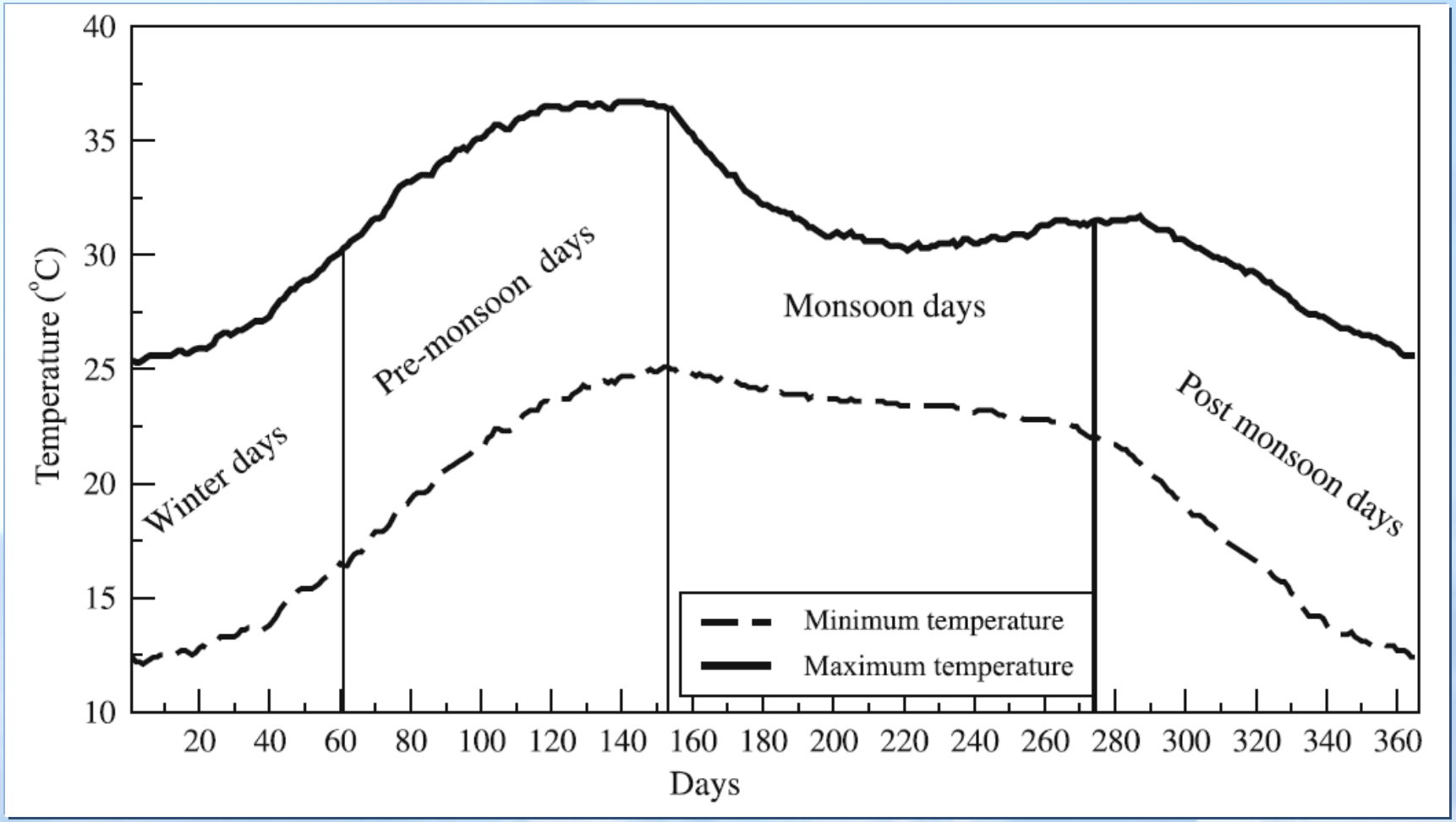
How India Meteorological Department (IMD) monitors the Heat wave

- IMD has a big network of surface observatories covering entire country to measure various metrological parameters like Temperature, Relative humidity, pressure, wind speed & direction etc.
- Based on daily maximum temperature station data, climatology of maximum temperature is prepared for the period 1981-2010 to find out normal maximum temperature of the day for particular station.
- Thereafter, IMD declared heat wave over the region as per its definition.

Maximum Temperature Climatology

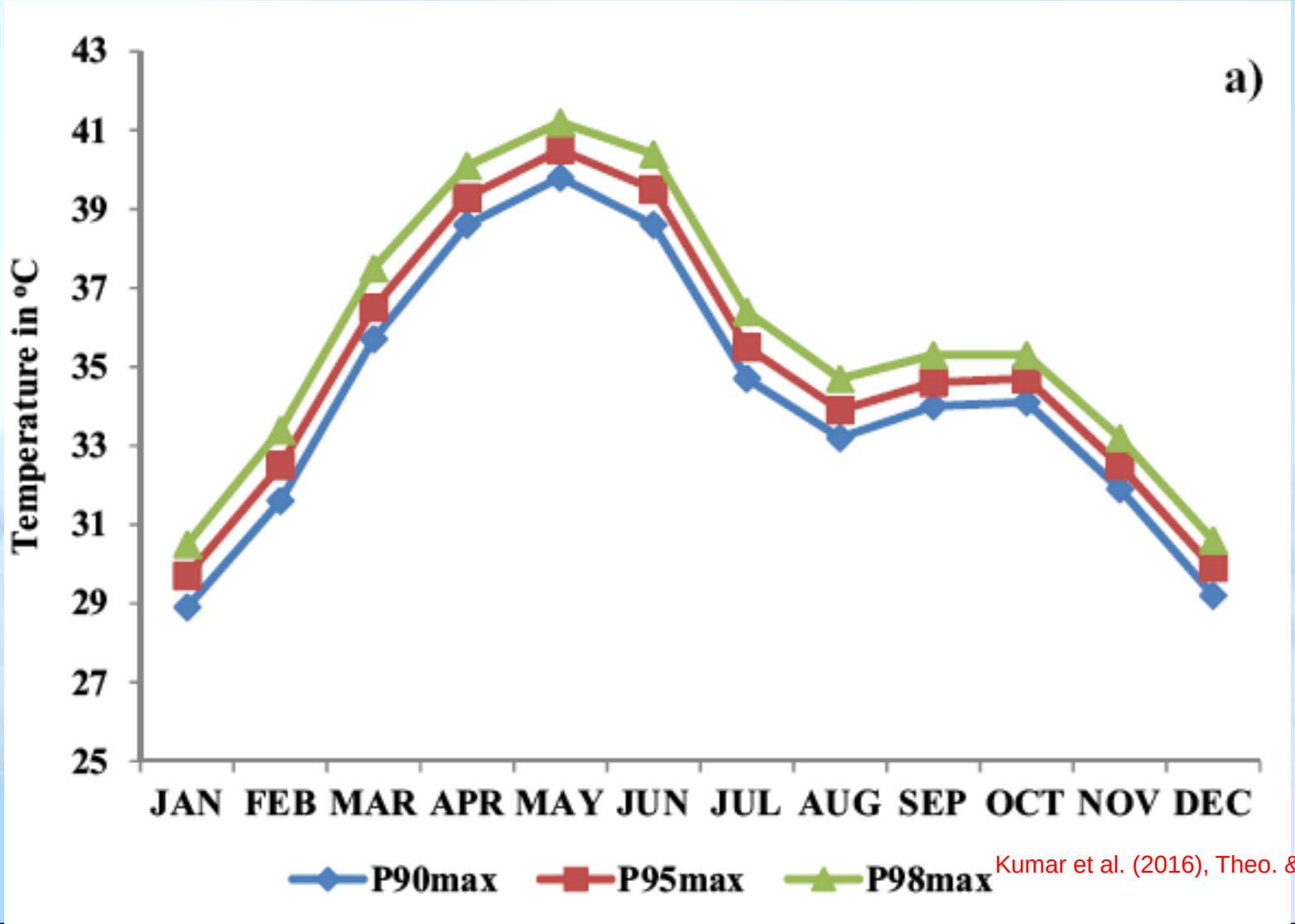


Annual cycle of All-India daily maximum and minimum temperatures

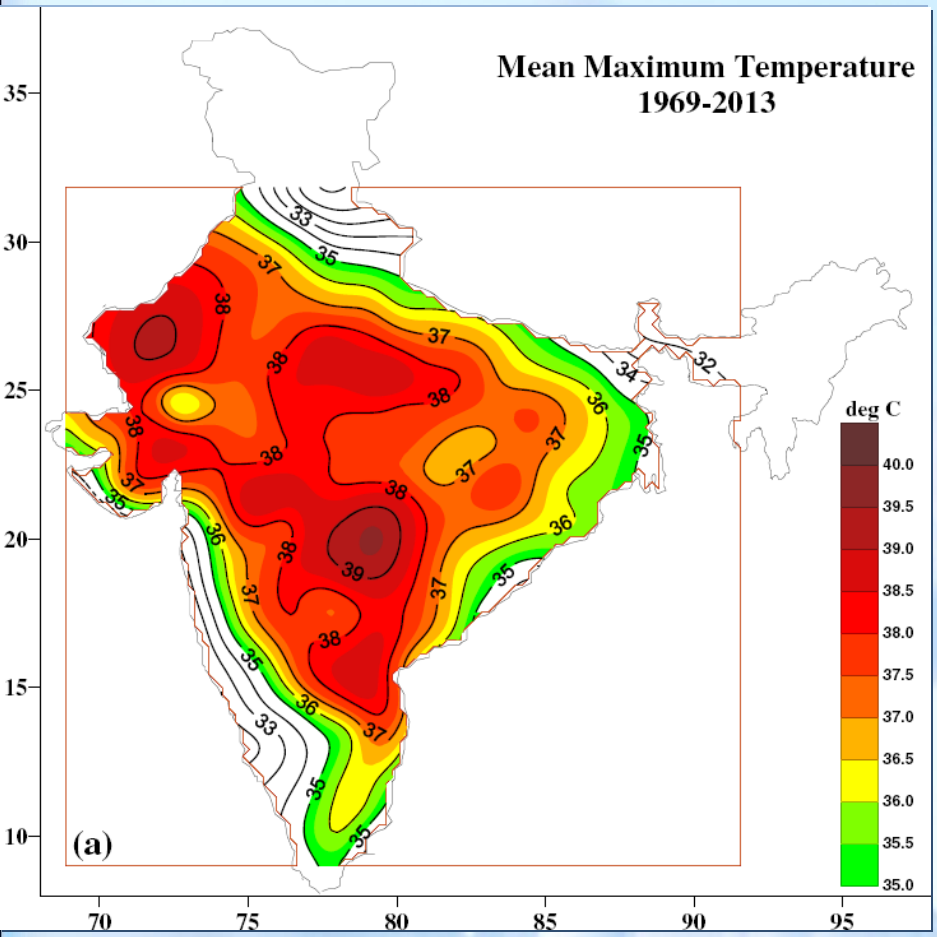


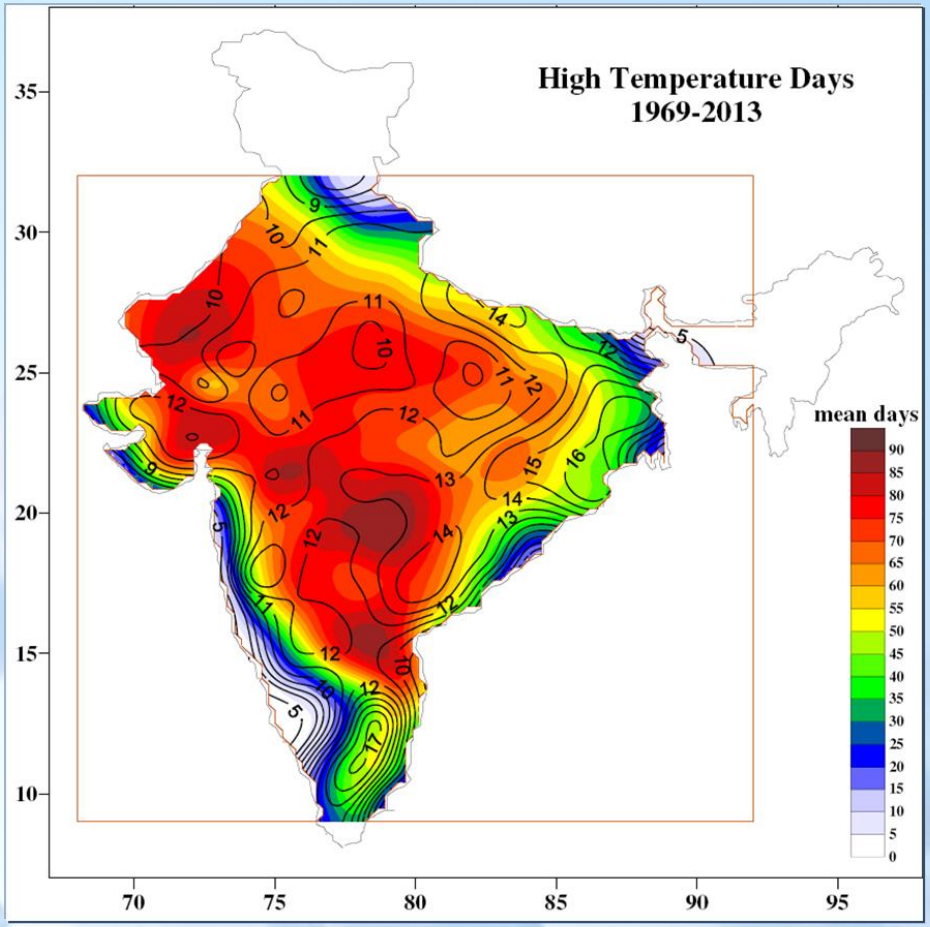
Kothawale et al. (2010), *J. Earth Syst. Sci*

Annual cycle of all India mean climatological thresholds of a maximum temperature P90max, P95max, P98max



Kumar et al. (2016), Theo. & App. Climat.





March-June
1969-2013
176 Stations

Jaswal et al. (2015), *J. Earth Syst. Sci*

Heat Wave over India

During hot weather period (March to July) surface temperatures over many parts of India abnormally shoot up, particularly over North India.

- *Heat wave occurs mostly over an interior plain area when dry and warmer air is transported in a region with clear skies and hence maximum insolation during the summer season.*
- *Bay islands, Lakshadweep, Tamil Nadu, Kerala, Coastal and South Interior Karnataka are not affected by heat waves due to the occurrence of maritime air over these regions.*
- *Heat waves generally develop over Northwest India and spread gradually eastwards & southwards but not westwards* (since the prevailing winds during the season are westerly to northwesterly). But on some occasions, heat wave may also develop over any region in situ under the favorable conditions.

Heat trough along East Coast

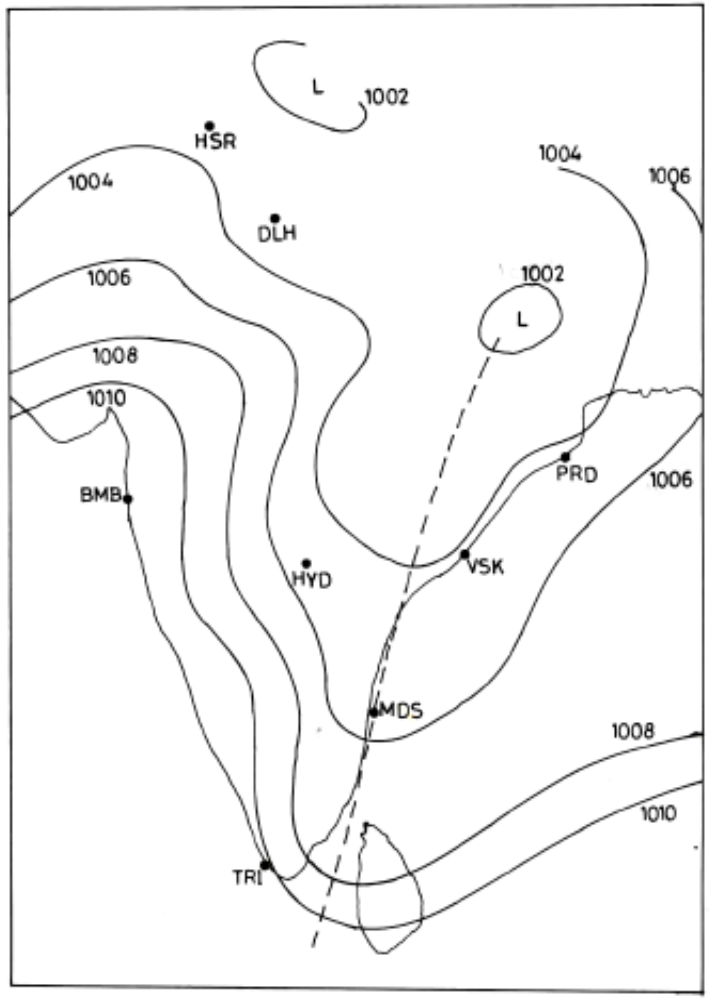


Fig. 6. Surface weather map at 0830 hrs IST on 31 May 2003

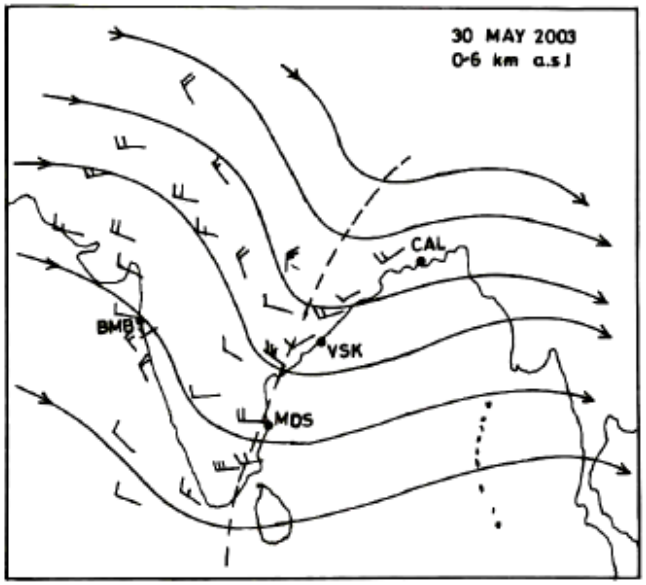


Fig. 7. Wind flow at 0530 hrs IST on 30 May 2003 at 0.6 km above sea level

Impact of strong and dry hot Nwly Winds

Highest Max Temp extend and/or shift to coastal stations

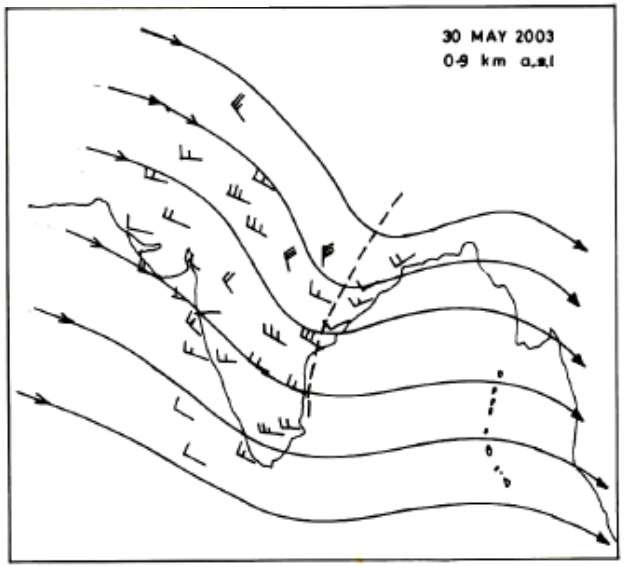
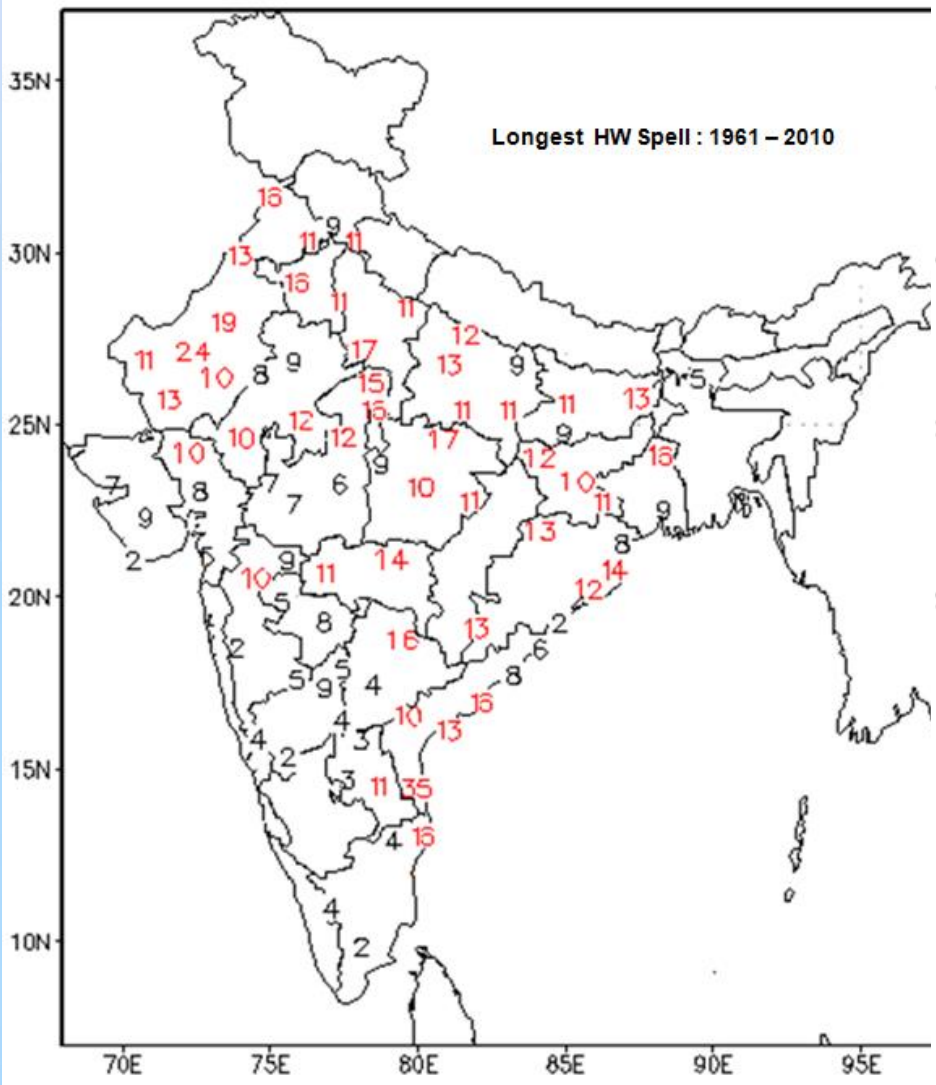
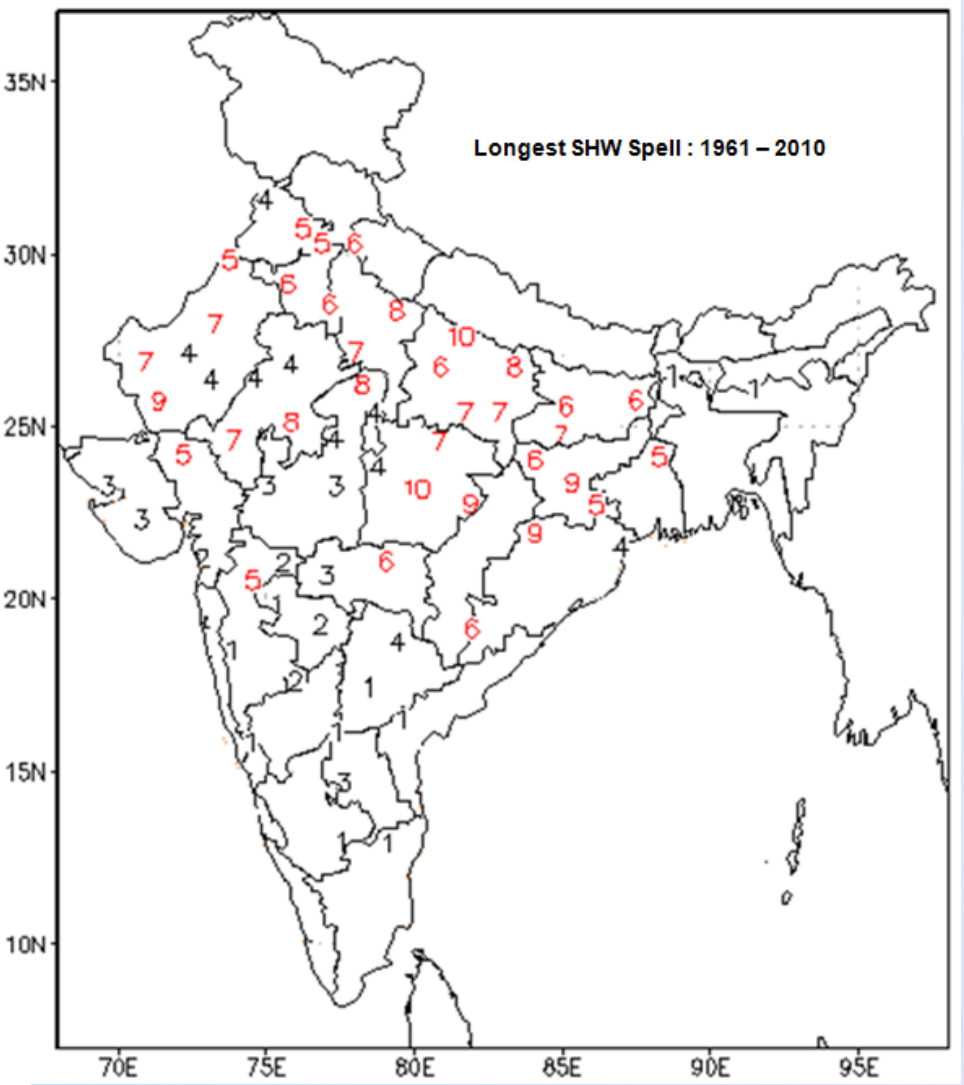


Fig. 8. Wind flow at 0530 hrs IST on 30 May 2003 at 0.9 km above sea level

Persistency of HW/SHW events



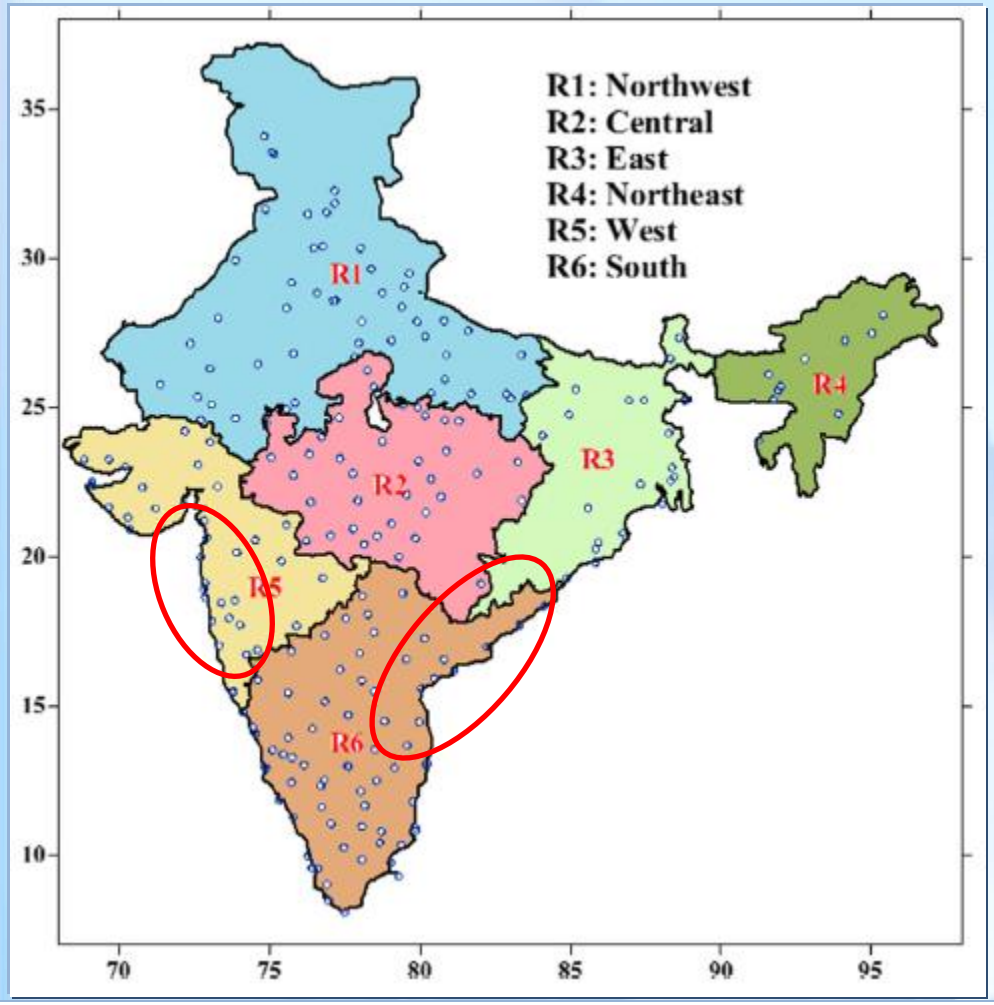


Pai et al.

Heat Wave over India

- The duration of the heat wave is in general 5 to 6 days but sometimes it may go up to 10 days or more. However, severe heat wave generally does not last for more than a day or two outside Bihar platue, where it may persists for as much as 4 to 5 days.
- Maximum frequency of heat waves over most of the states is found to be in the month of May.
- However, the number of heat waves over Bihar, Rajasthan and Uttar Pradesh (UP) is more during the month of June compared to other months.
- The causalities due to heat waves are more over the regions where the normal maximum temperature itself is more than 40°C.

HD, VHD & EHD trend during 1969-2012



		Number of stations in %						
Index	Trend	India	R1	R2	R3	R4	R5	R6
HD	Increasing	40	41	57	14	50	24	47
	Increasing significantly	*27*	*20*	*14*	*19*	*30*	*49*	*29*
	Decreasing	26	33	26	38	20	24	19
	Decreasing significantly	*7*	*6*	*3*	*29*	*0*	*3*	*5*
VHD	Increasing	38	41	46	14	40	22	47
	Increasing significantly	*26*	*16*	*20*	*19*	*40*	*51*	*25*
	Decreasing	29	31	34	38	20	24	25
	Decreasing significantly	*7*	*12*	*0*	*29*	*0*	*3*	*4*
EHD	Increasing	39	39	43	24	10	35	48
	Increasing significantly	*24*	*18*	*20*	*5*	*40*	*38*	*26*
	Decreasing	30	27	37	57	50	22	23
	Decreasing significantly	*7*	*16*	*0*	*14*	*0*	*5*	*3*

Out of 227 stations, 67% shows increasing trend in HD and 63% in EHD. In R5 & R6, 73% & 74% respectively stations indicate increasing trend in EHD during 1969-2012.

Kumar et al. (2016), Theoretical & applied climatology

Averaged over India, the summer hot days indices HD, VHD, and EHD are increasing at the rate of +1.0, +0.64, and +0.32 days/decade, respectively, and winter cold night indices CN, VCN, and ECN are decreasing at the rate of −0.93, −0.47, and −0.15 days/decade, respectively,

HD, VHD & EHD trend during 1969-2012

Station	Population (millions)	Trends in days/decade		
		HD	VHD	EHD
Mumbai (Santacruz)	18.41	0.88	0.51	−0.14
Mumbai (Colaba)		3.26*	2.01*	0.32
New Delhi (Palam)	16.31	−0.20	−0.37	−0.34
New Delhi (Safdarjung)		0.65	0.10	0.31
Kolkata (Alipore)	14.11	−1.73*	−1.25*	−0.62*
Kolkata (Dum Dum)		−0.20	−0.48	−0.34
Chennai (Nungambakkam)	8.70	0.85	0.77	0.34
Chennai (Minambakkam)		0.67	0.50	0.37
Bangalore	8.50	0.77	0.52	0.33
Hyderabad	7.75	1.45*	0.83	0.64*
Ahmedabad	6.35	−0.99	−0.26	0.18
Pune	5.05	−0.10	−0.16	−0.08
Surat	4.59	−0.52	−0.46	−0.50*
Jaipur	3.07	1.55*	1.02	0.74*

Out of 14 stations, 8 shows increasing trend in HD and EHD.

Kumar et al. (2016), Theoretical & applied climatology

Impact based heat wave early warning mechanism of IMD

(Three Tier Forecasting Structure)

Level	Responsibility
	National
NWFC	Met Subdivision Forecasting/Warning, Guidelines Developmental work
PUNE	Documentation , Reports, National tools/Techniques
	Regional
RMCs (06)	District-wise Forecasting/warning, other Forecasts
	Local
MCs (21)	District-wise Forecasting/warning, other Forecasts

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INDIA METEOROLOGICAL DEPARTMENT
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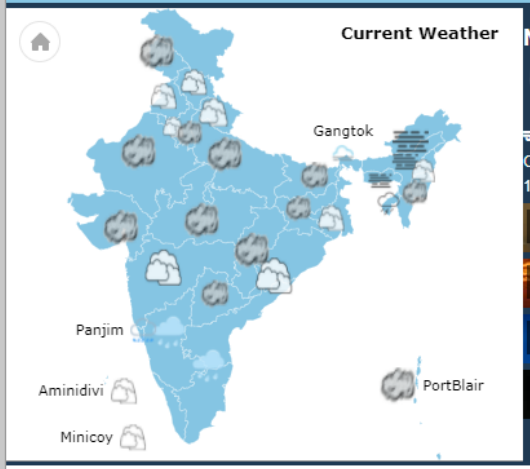
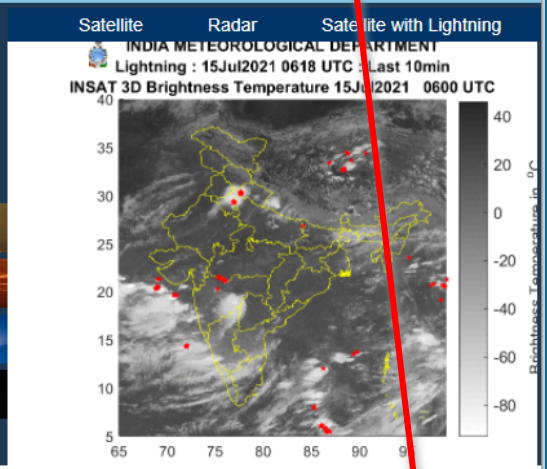
Specialized Forecasts

NG DELHI ♦ Southwest Monsoon has advanced into Delhi today, the 13th July, 2021. ♦ Press Release on Advance of monsoon over Delhi ♦ Further Advance o



New Delhi
35.3°C
56%
Easterly 7.5 km/h
Observation time : 2021-07-15 11.30 IST
Sunrise: 05:34 (IST)
Sunset: 19:22 (IST)
Moonrise: 10:22 (IST)
Moonset: 23:08 (IST)



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All India Heat Wave Information

Daily impact based Heat Wave warning Bulletin | Extended Outlook for next 2 weeks | Seasonal Forecast Outlook | FDP Heat Wave Warning Report |

Interactive Map for Actual Temperature and heatwave | Interactive Map last 5 days Temperature and heatwave: Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |

Interactive Map for forecast Temperature and heatwave Today | Day 1 | Day 2 | Day 3 | Day 4 |

Normal Relative humidity at 0830 & 1730 hours IST : (March - Morning | Evening) | (April - Morning | Evening) | (May - Morning | Evening) | (June - Morning | Evening) |

Station wise threshold of maximum temperatures based on percentile method | Heat wave Definition | FAQ on Heat Wave | Heat wave warning skills of IMD |
NDMA heat wave guidelines |

FDP on Heat wave

- Two special heat wave bulletins are issued daily during FDP period (1 March to 30 June), 1st bulletin issued at 0800 hours IST with observed temperatures and heat wave warning for the same day, 2nd detailed heat wave warnings bulletin with observed maximum/minimum temperatures, Relative humidity & temperatures based on 1430 hours IST are issued at 1600 hrs IST other than 4 times multi-hazards warning bulletins.
- Warnings at meteorological sub-division levels issued to different users like, MHA, NDMA, SDMA, CS of states, DC/DM of different districts of states, health department, Indian Railway, Road transport, Media etc.
- A colour code impact based alert.
- Seasonal and extended range (upto two weeks) outlook.
- District level heat wave warning (upto five days) by State Meteorological Centre

Impact of Heat Wave Warning

Warning	Impact	Suggested Actions
Nil	Comfortable temperatures	No cautionary action required
Heat wave conditions at district level, likely to persist for 2 days	Heat is tolerable for general public but moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	Avoid heat exposure
i. Severe heat wave conditions likely to persist for 2 days. ii. With varied severity, heat wave is likely to persist for 4 days or more.	Increased likelihood of heat illness symptoms in people who are either exposed to sun for a prolonged period or doing heavy work. High health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	Avoid heat exposure– keep cool. Avoid dehydration
i. Severe heat wave likely to persist for more than 2 days. ii. Total number of heat/severe heat wave days likely to exceed 6 days.	Very high likelihood of developing heat illness and heat stroke in all ages.	Extreme care needed for vulnerable people.

Daily Impact Based Heat Warning Bulletin

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

Dated: 08th July, 2021
Time of Issue: 1600 Hours IST

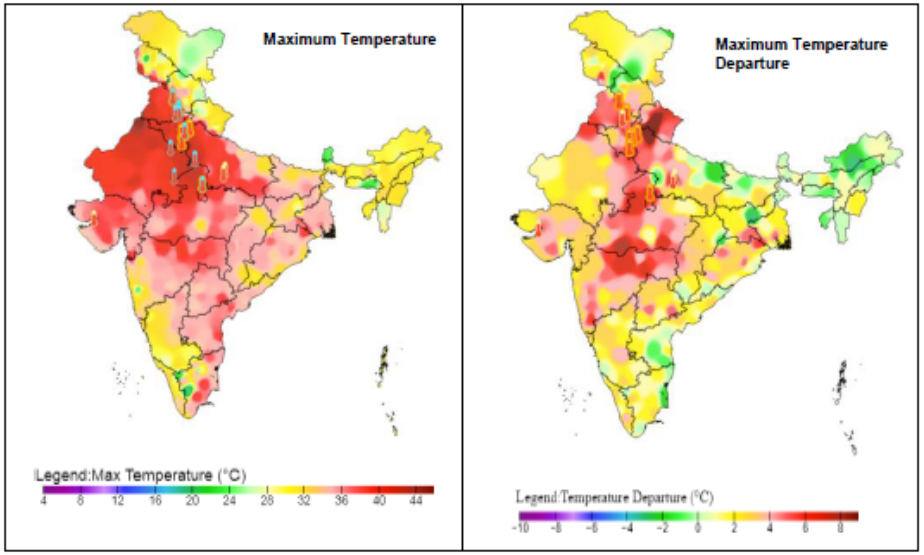
Current Temperature Status and Warning for next five days

Yesterday's Maximum Temperature Scenario:

Heat Wave:- Yesterday, Heat wave observed in many pockets over Haryana, Chandigarh & Delhi and in isolated pockets over Punjab, West Uttar Pradesh and West Madhya Pradesh.

Maximum Temperature:- Maximum temperatures more than **40.0°C** were recorded at many places over Haryana, Chandigarh & Delhi, Punjab and West Rajasthan; at a few places over East Rajasthan and West Uttar Pradesh and at isolated places over West Madhya Pradesh.

Yesterday, the **highest maximum temperature** of **45.5°C** was reported at **Ganganagar (West Rajasthan).**



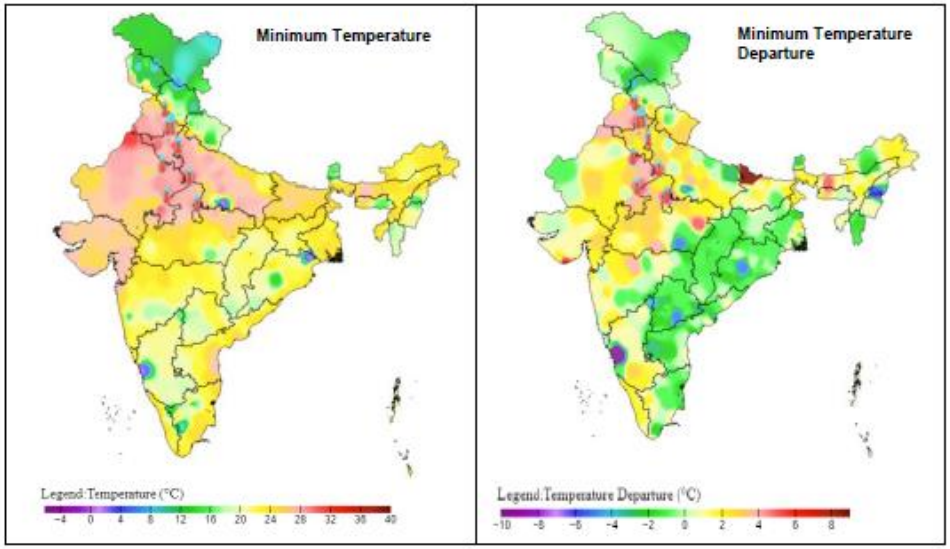
Mausam Bhawan, Lodi Road, New Delhi – 110 003
Phones: 24611068, 24618241-47; Fax No. 24699216, 2423220, 24643128

Today's Minimum Temperature Scenario:

Warm Night:- NIL.

Minimum Temperature:-Over heat wave expected areas Minimum temperatures are in the range of 26-30 °C over most parts of Punjab, Haryana, Chandigarh & Delhi, Rajasthan and West Uttar Pradesh.

Minimum temperatures are **appreciably above normal (3.1°C to 5.0°C)** at many places over Punjab, ; at isolated places over East Rajasthan and West Madhya Pradesh; **above normal (1.6°C to 3.0°C)** at most places over Uttarakhand, Gujarat region and Sub-Himalayan West Bengal & Sikkim and Kerala & Mahe; at a few places over Uttar Pradesh, Bihar, Marathawada; at isolated places over East Madhya Pradesh, Madhya Maharashtra and North Interior Karnataka.



Daily Impact Based Heat Warning Bulletin

Heat Wave Warnings for Next 5 Days

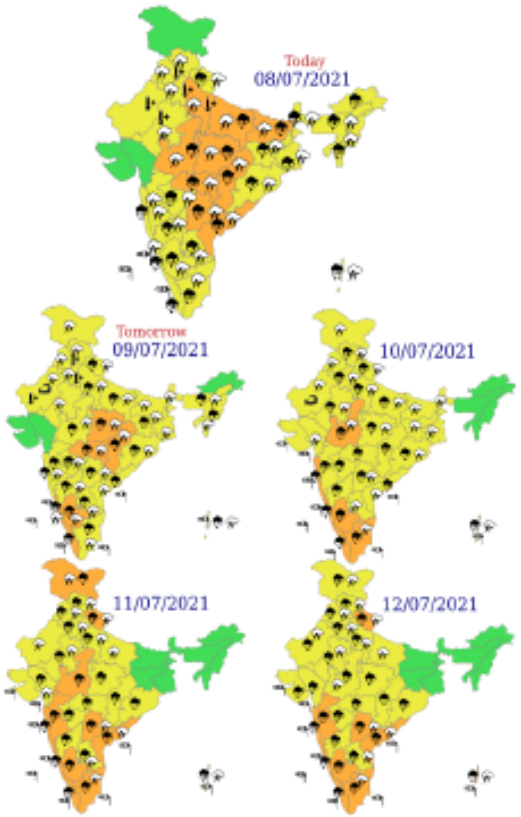
DAY-1:- Heat Wave conditions very likely in isolated pockets over Punjab, Haryana, Chandigarh & Delhi, West Uttar Pradesh and Rajasthan.

DAY-2:- Heat Wave conditions very likely in isolated pockets over Punjab, Haryana, Chandigarh & Delhi and West Rajasthan.

DAY-3:- NIL.

DAY-4:- NIL.

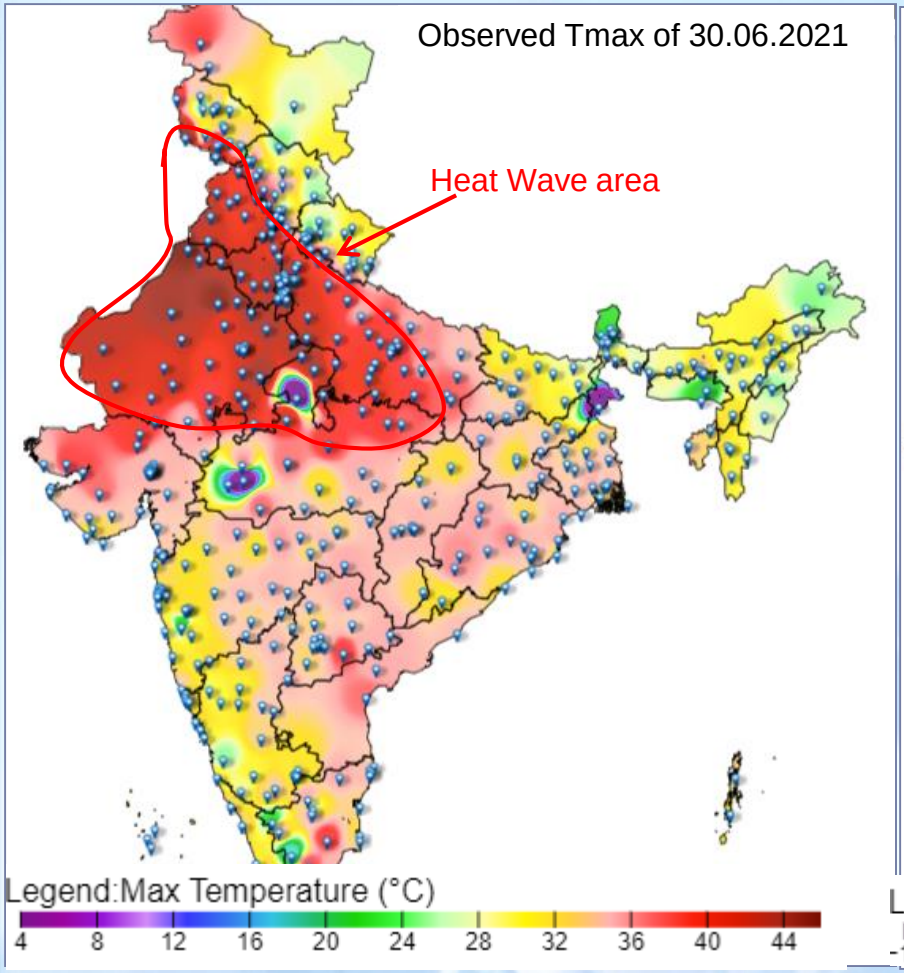
DAY-5:- NIL.

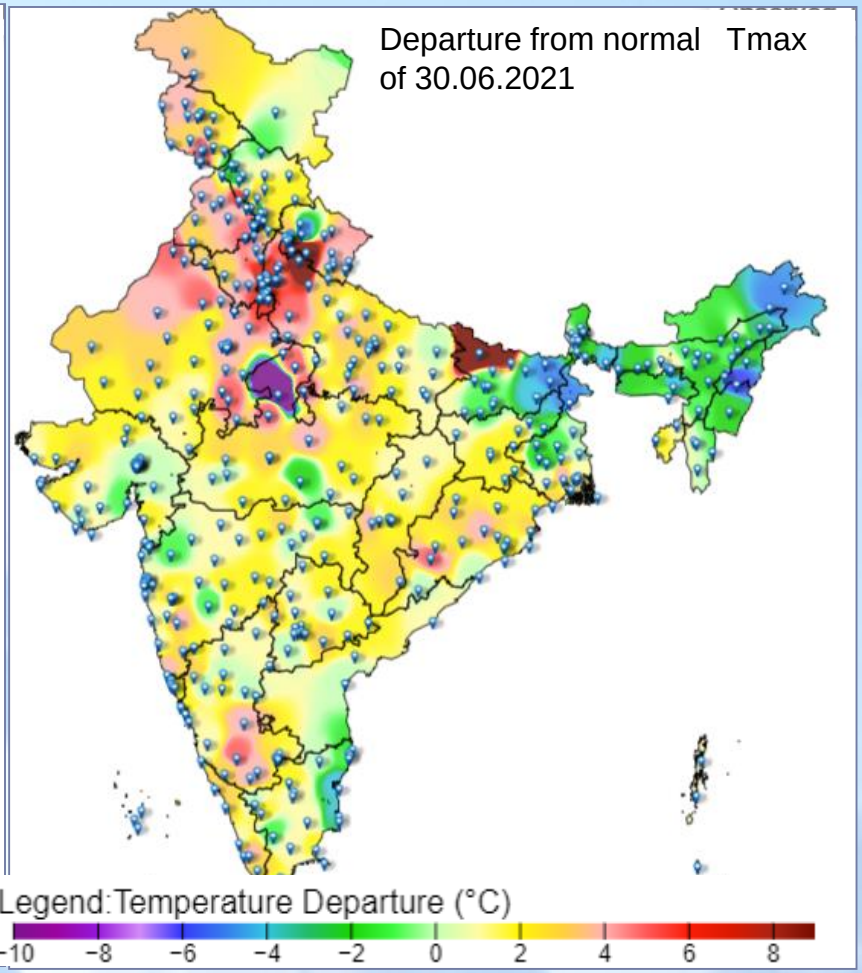


Impact of heat wave and action suggested

Heat wave could lead to moderate health concern for vulnerable people e.g. infants, elderly, People with chronic diseases over the heat wave areas specifically over Punjab, Haryana, Chandigarh & Delhi, Rajasthan and West Uttar Pradesh. Hence people of these regions should avoid heat exposure, wear lightweight, light-colored, loose, cotton clothes and cover the head by use of cloth, hat or umbrella etc.

Observed Maximum Temperatures





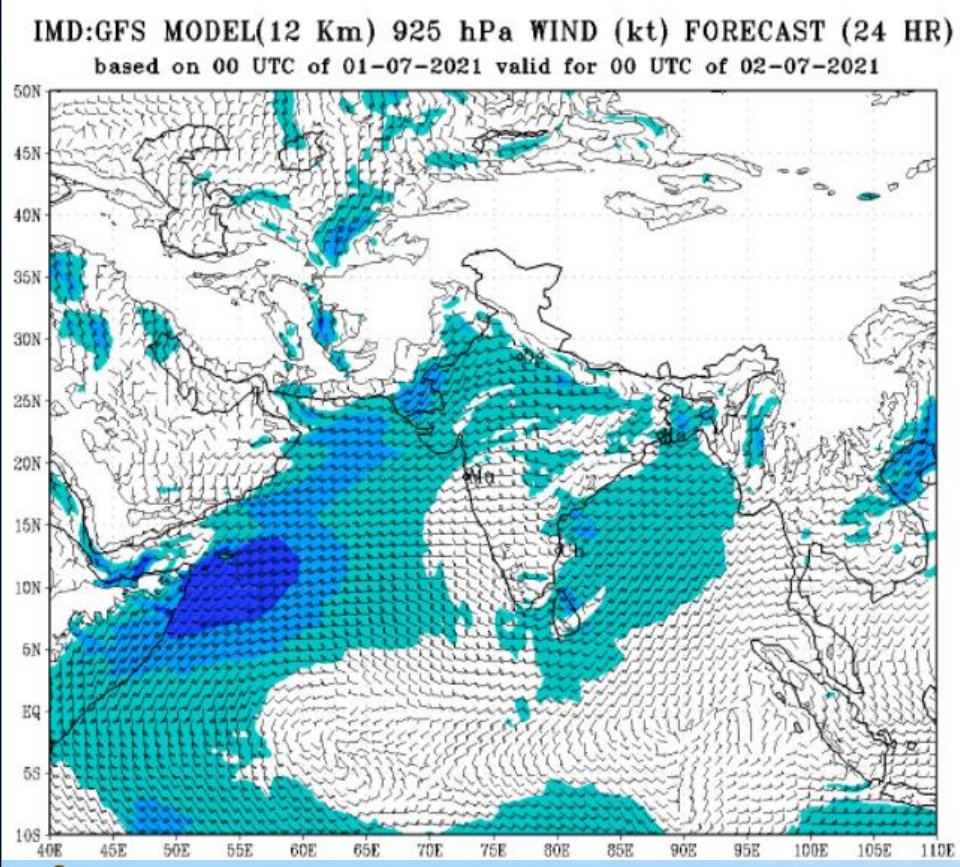
Heat Wave Conditions in many places over Punjab, Haryana & Chandigarh and West Uttar Pradesh and in isolated places over Jammu division, West Rajasthan and Northwest Madhya Pradesh.

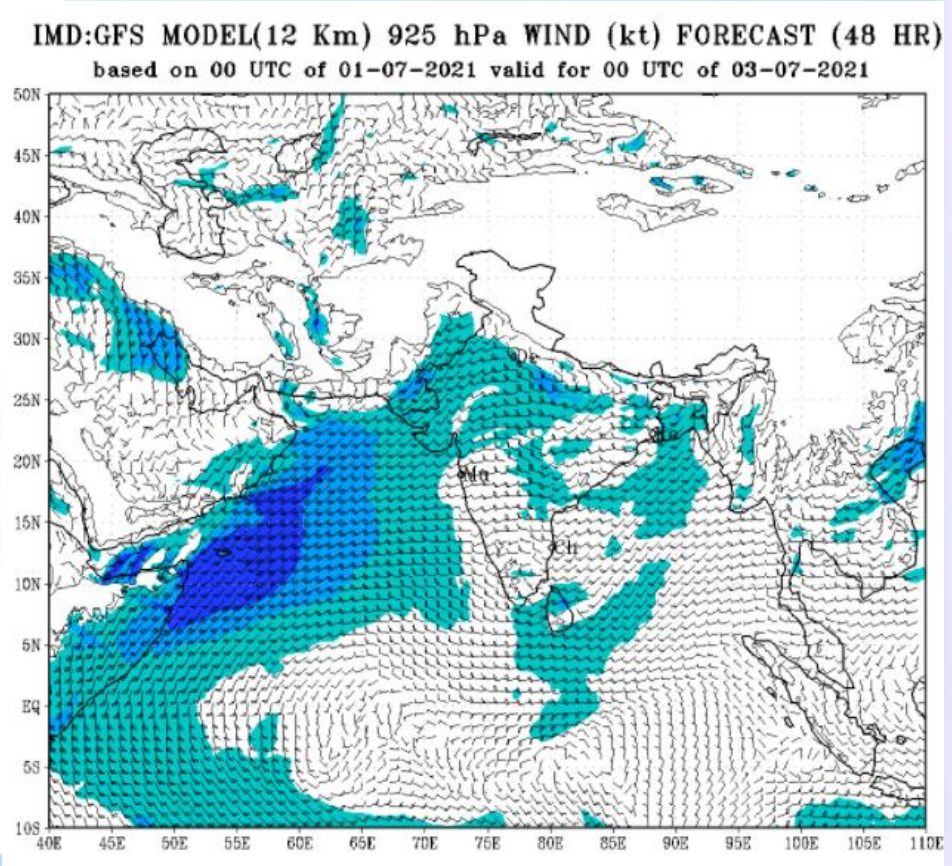
(http://imdgeospatial.imd.gov.in/Min_Temperature_Day1/#5/27.079/82.793)

Heat Wave forecast

01.07.2021: Heat Wave conditions in some pockets very likely over Punjab, Haryana, Chandigarh & Delhi and at isolated pockets over Uttar Pradesh, north Rajasthan and northwest Madhya Pradesh.

02.07.2021: Heat Wave conditions in isolated pockets very likely over Punjab, Haryana, Chandigarh & Delhi, West Uttar Pradesh and north Rajasthan.





Extended weekly Impact Based Heat Warning Bulletin (every Thursday)

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

Dated: 01 April, 2021

Summer Temperature & Heat Wave: Current Status and Outlook for next two weeks (01 to 14 April, 2019)

Temperature Scenario of the past week (25 to 31 March, 2021)

- The maximum temperatures were above normal by 2 to 4°C over most parts of plains of northwest India, Gujarat, Chhattisgarh, Odisha & West Bengal; were above normal by 2 to 3°C over most parts of northeast India, Western Himalayan Region and central India. These were near normal over remaining parts of the country (**Annexure I**).
- Heat wave to severe heat wave conditions occurred over Saurashtra & Kutch and West Rajasthan on many days; over Konkan & Goa on few days; Heat wave conditions at isolated places occurred over East Rajasthan, Gujarat Region, Madhya Pradesh, West Uttar Pradesh, Jharkhand, Vidharbha, Coastal Andhra Pradesh & Yanam, Tamil Nadu, Puducherry & Karaikkal on one or two days of the week.
- The highest maximum temperature of 44.6° C recorded at Baripada (Odisha) on 30th March 2021 (**Annexure II**).

Chief synoptic conditions as on 01 April, 2021

- A **Well Marked Low Pressure Area** lies over Central parts of Andaman Sea & neighbourhood. It is likely to concentrate into a Depression over the same region during next 24 hours. It is likely to move northeastwards towards Myanmar coast.
- A trough in westerlies runs roughly along Long. 84°E to the north of Lat. 25°N between 3.1 & 3.6 km above mean sea level.
- A cyclonic circulation lies over Sri Lanka & adjoining Comorin area between 1.5 km & 3.6 km above mean sea level.
- A north-south trough runs from North Interior Karnataka to South Tamilnadu at lower levels.
- A fresh Western Disturbance is likely to affect Western Himalayan Region from the night of 03rd April.

Large scale features as on 01 April, 2021

- Currently, moderate La Niña conditions are prevailing over equatorial Pacific and Sea Surface Temperatures (SSTs) are below normal over central & eastern equatorial Pacific Ocean. The latest Monsoon Mission Climate Forecasting System (MMCFS) forecast indicates warming of SSTs over Nino 3.4 region during the coming season and there is a possibility of transition of La Niña conditions to ENSO neutral conditions during the forthcoming season. However, model skill during this period is supposed to be limited because of the spring barrier.
- At present, neutral Indian Ocean Dipole (IOD) conditions are observed over Indian Ocean and the latest MMCFS forecast indicates neutral IOD conditions are likely to continue up to May, June & July (MJJ) months and negative IOD conditions likely to develop thereafter.
- The Madden Julian Oscillation (MJO) index lies in Maritime Continent (Phase 5) with high amplitude. As per the latest projections, it is likely to move over Western Pacific (Phase 6) with high amplitude during next one week.

Temperature for week 1: (01 to 07 April, 2021)

- Yesterday's maximum temperatures were markedly above normal (5.1°C or more) at a few places over Gangetic West Bengal and Coastal Andhra Pradesh & Yanam and at isolated places over Odisha and Telangana; appreciably above normal (3.1°C to 5.0°C) at many places over Uttarakhand and West Uttar Pradesh; at a few places over Himachal Pradesh, Haryana, Chandigarh & Delhi, Saurashtra & Kutch, South Interior Karnataka and Rayalaseema.
- No significant change in maximum temperatures over most parts of Northwest & adjoining central India during 1st half of the week 1 and very likely to fall by 2-4°C during its 2nd half. Maximum temperatures very likely to fall by 2-3°C over most parts of East India during 1st half of the week 1 and very likely to fall by 2-4°C during its 2nd half. No significant change in maximum temperatures over rest parts of the country during next one week.
- Hence no major heat wave spell is likely over any part of the country during next one week. **However, heat wave at isolated places very likely over Gujarat on 2nd & 3rd; Southwest Rajasthan on 3rd & 4th; Vidharbha on 4th & 5th; south Andhra Pradesh on 2nd and over Tamilnadu till 4th** April, 2021. No heat wave likely over remaining parts of the country during week 1.

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Extended weekly Impact Based Heat Warning Bulletin (every Thursday)

Temperature for week 2: (08 to 14 April, 2021)

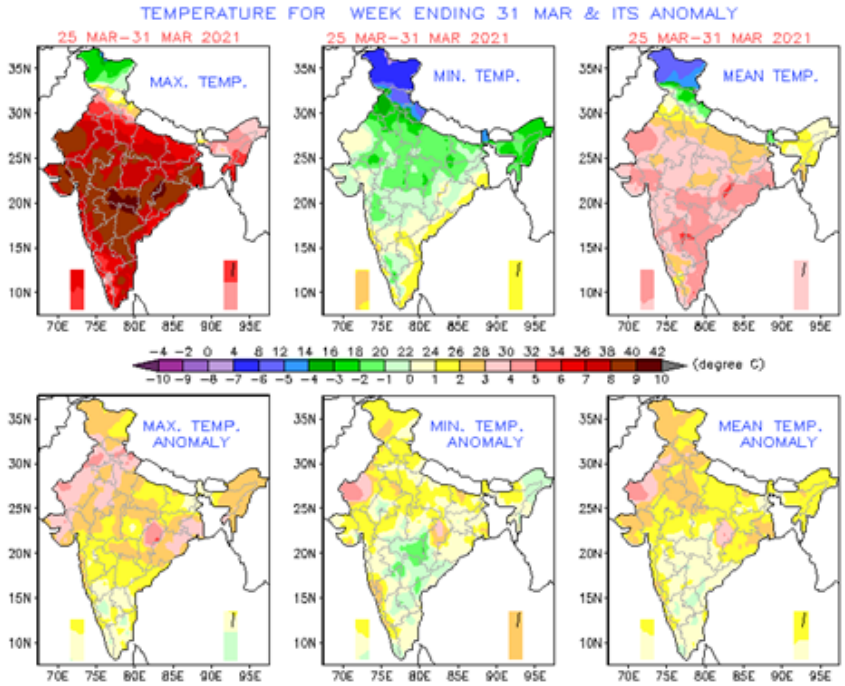
- During week 2, maximum temperatures are very likely to rise gradually over northern parts of the country and along the east coast. Hence, normal to above normal maximum temperatures likely along East Coast including Odisha and near normal over northern parts of the country and Saurashtra & Kutch **(Annexure III)**. **Hence, there is moderate probability of getting heat wave at isolated places over Odisha, Andhra Pradesh and Saurashtra & Kutch and south Rajasthan during week 2.**

Impact of heat wave and action suggested

- **Heat wave could be moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases over the heat wave areas specifically over coastal Tamilnadu & Andhra Pradesh due to availability of high humidity over these regions. Hence public of these regions should avoid heat exposure, wear lightweight, light-coloured, loose, cotton clothes and cover the head by use of cloth, hat or umbrella etc.**

Next weekly update will be issued on next Thursday i.e. 08 April, 2020

Annexure I



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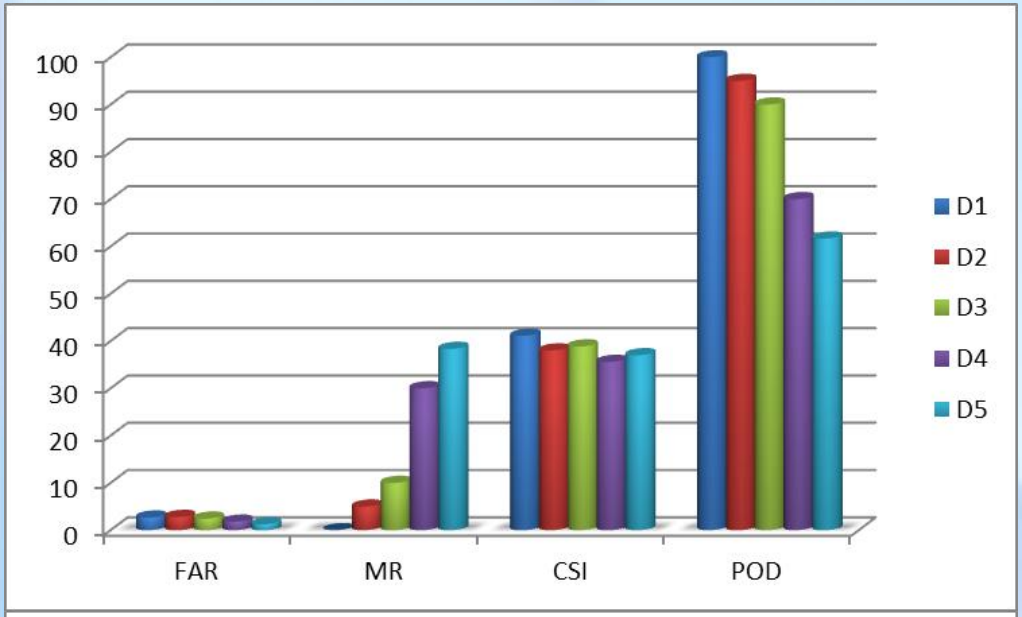
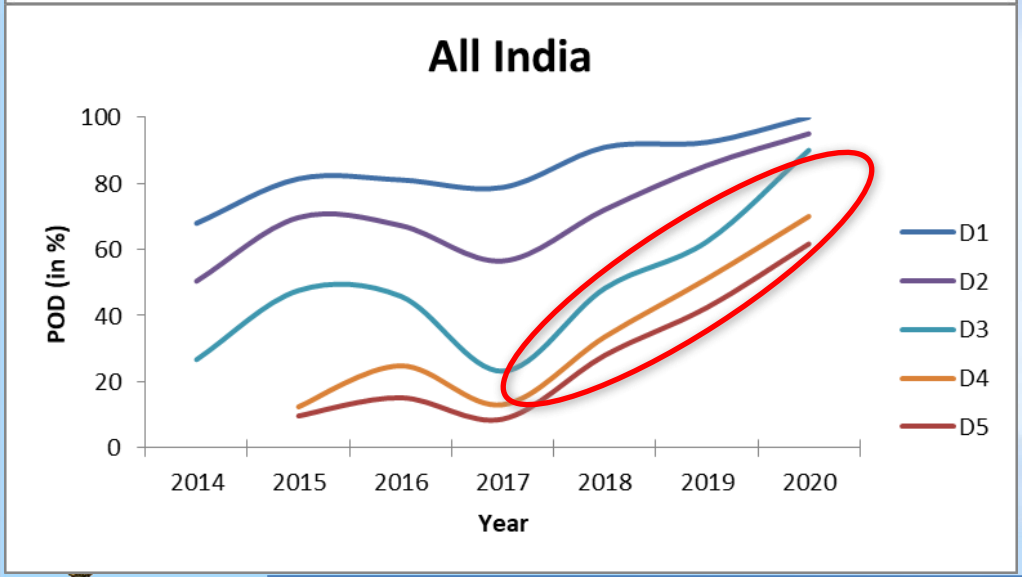
Heat wave warning skill



High heat wave warning skill during 2020, Probability of Detection (PoD) is between 100 to 60% between Day 1 to Day 5.



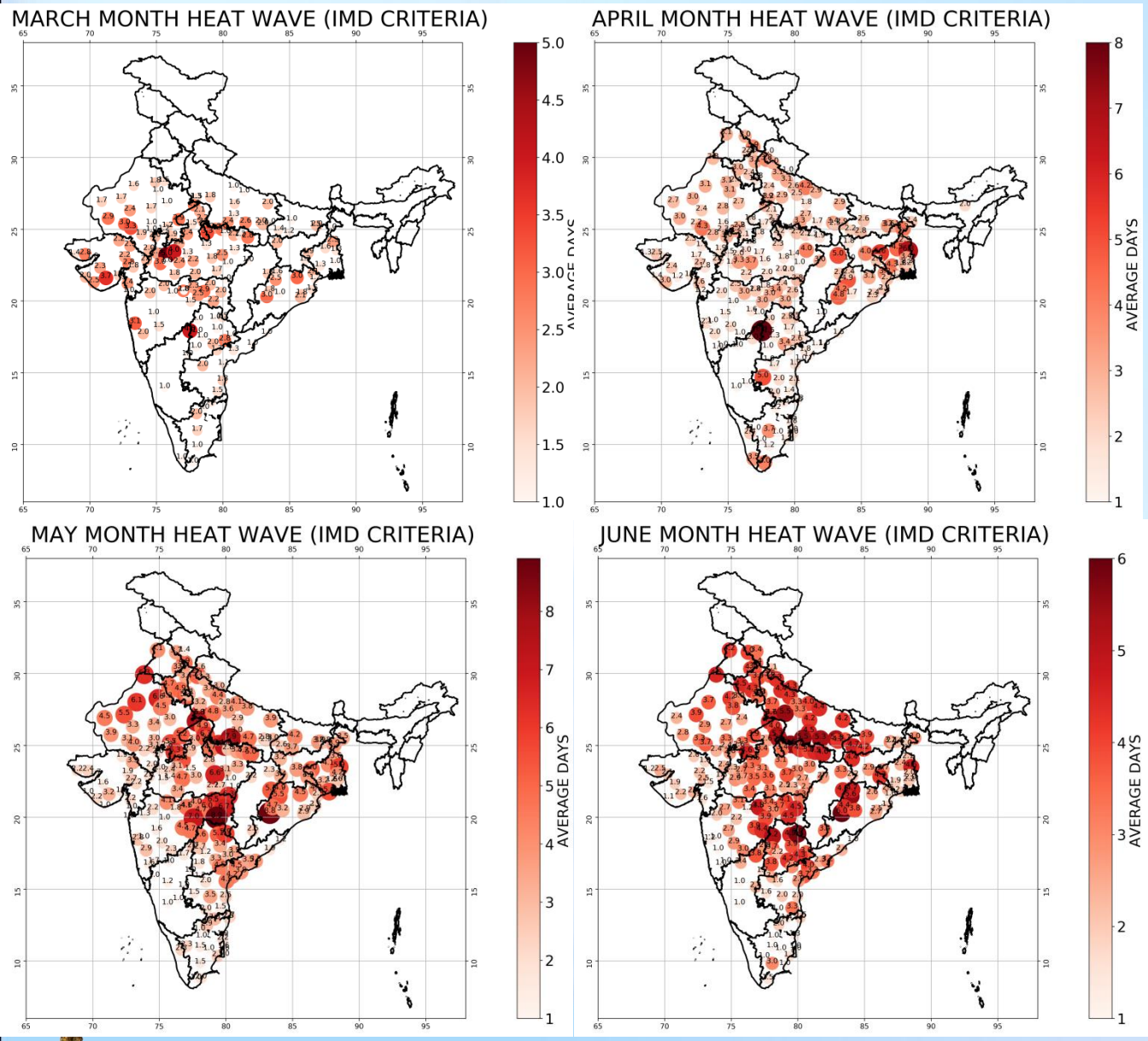
High improvement in skill scores specifically from Day 3 to Day 5.

Heat Wave Hazard Analysis by using maximum & minimum temperatures, humidity

Station wise Heat Wave Hazard Analysis

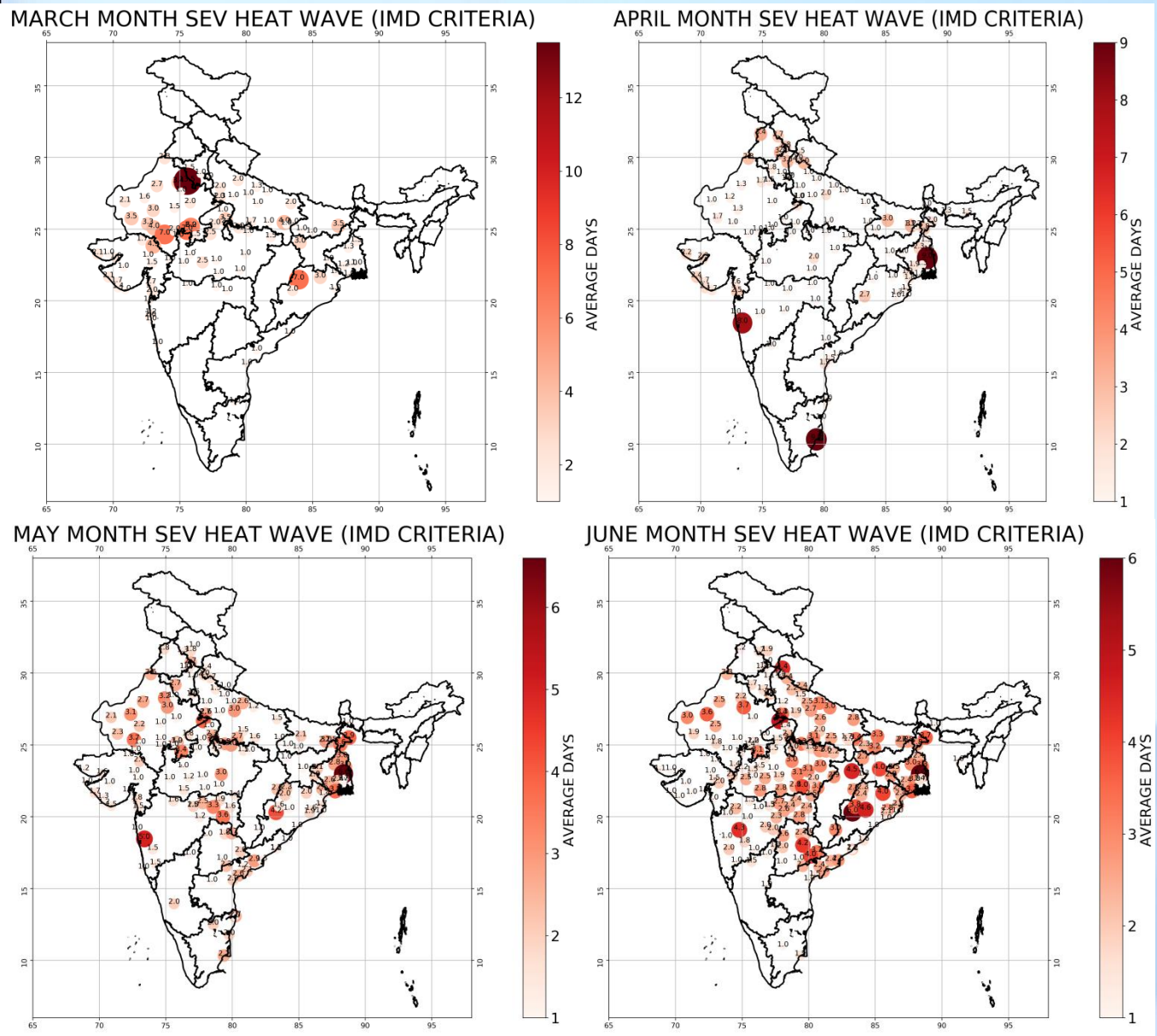
- Considered 296 stations covering entire country.
- Daily maximum and minimum temperature for the period 1971-2019 for March to June months.
- Calculated heat wave, severe heat wave and extremely severe heat wave by 90th, 95th & 98th percentile of March to June months for 1971-2010 period. Same is also calculated using IMD criteria.
- Similarly, calculated hot days, severe hot days and extremely severe hot days for the same period.
- Calculated daily 09 UTC (1430 hours IST) humidity, wind speed & direction for the same period on heat wave days.
- Finally giving the different weightage to each parameter, station wise monthly heat wave hazard analysis is prepared.

IMD-CRITERIA BASED (Heat Wave for different months)



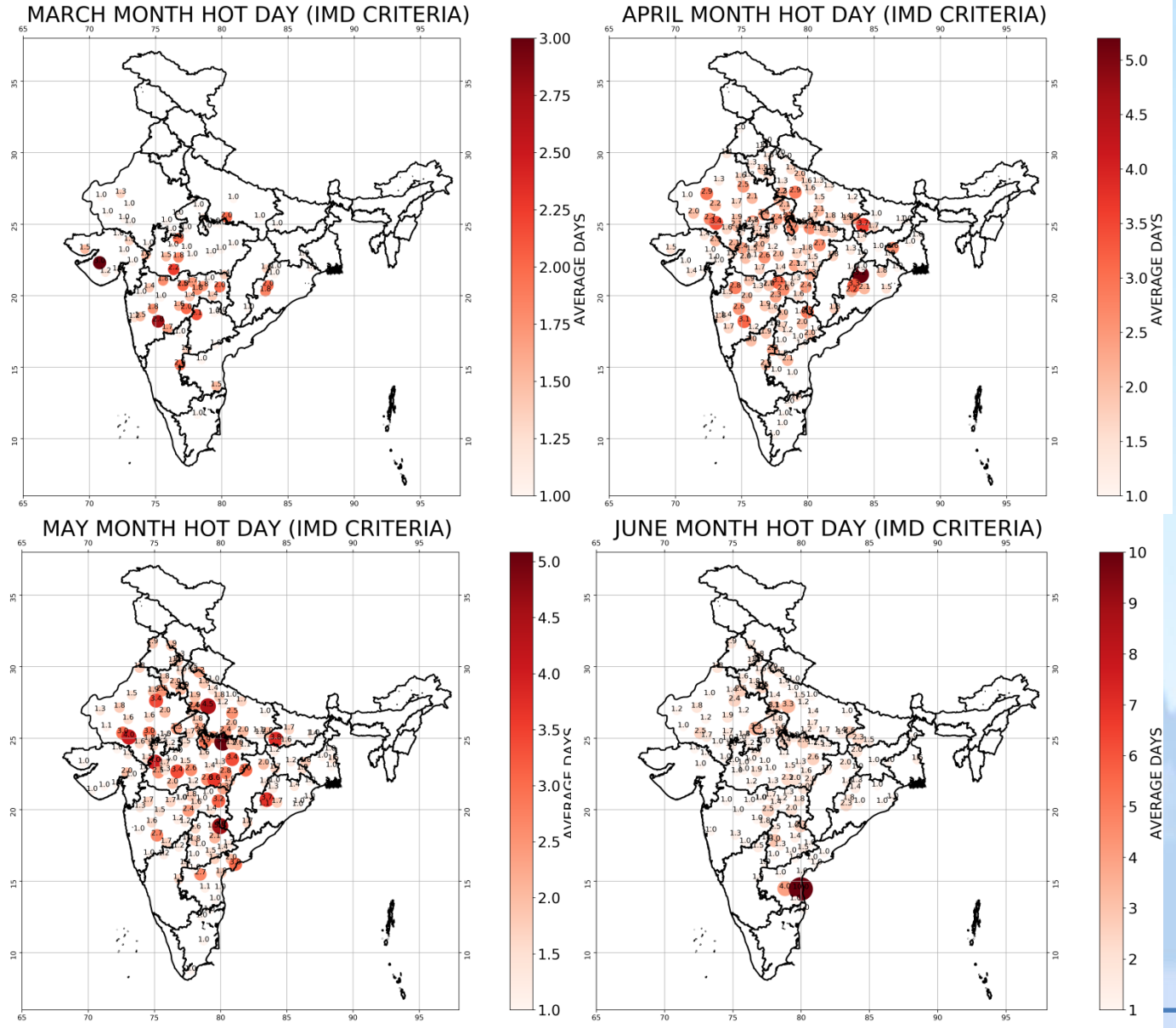
- Maximum number of Heat Wave Days are observed in month of May. They are largely concentrated around Vidarbha, northwest Rajasthan, south Uttar Pradesh, interior Odisha and adjoining areas.
- The distribution of Heat Wave days are more uniform during June with increase seen mostly around plains of north and northwest India as compared to month of May.

IMD-CRITERIA BASED (Severe Heat Wave for different months)



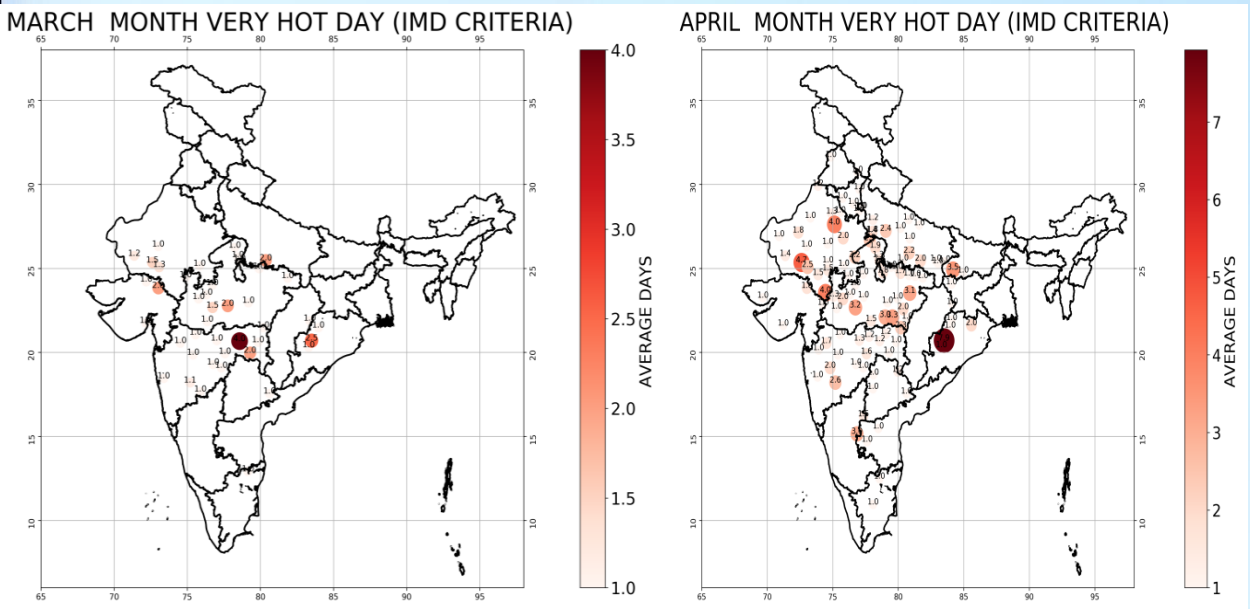
- Severe Heat Wave are more prevalent in month of June as compared to March to May.
- Severe Heat Wave events are more concentrated towards central India and east central parts of India during month of June, where as they are mostly concentrated towards Rajasthan and adjoining areas during the months of March to May.

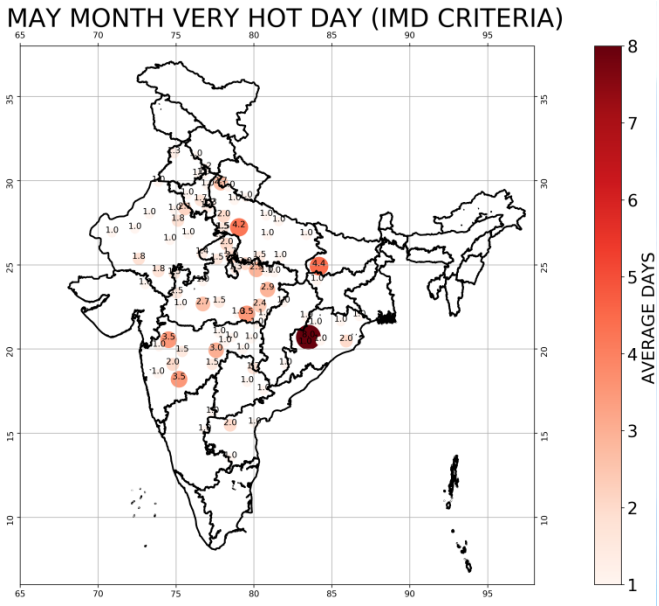
IMD-CRITERIA BASED (Hot Day for different months)

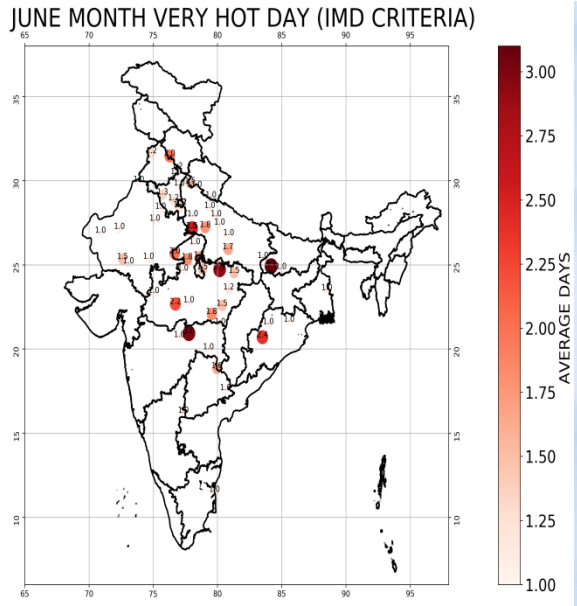


- Maximum number of average Hot Days are concentrated in month of April-May.
- The Hot day are concentrated towards west central parts of India during month of April.
- March and June witnesses the lowest number of very Hot days as compared to April and May.

IMD-CRITERIA BASED (Severe Hot Day for different months)

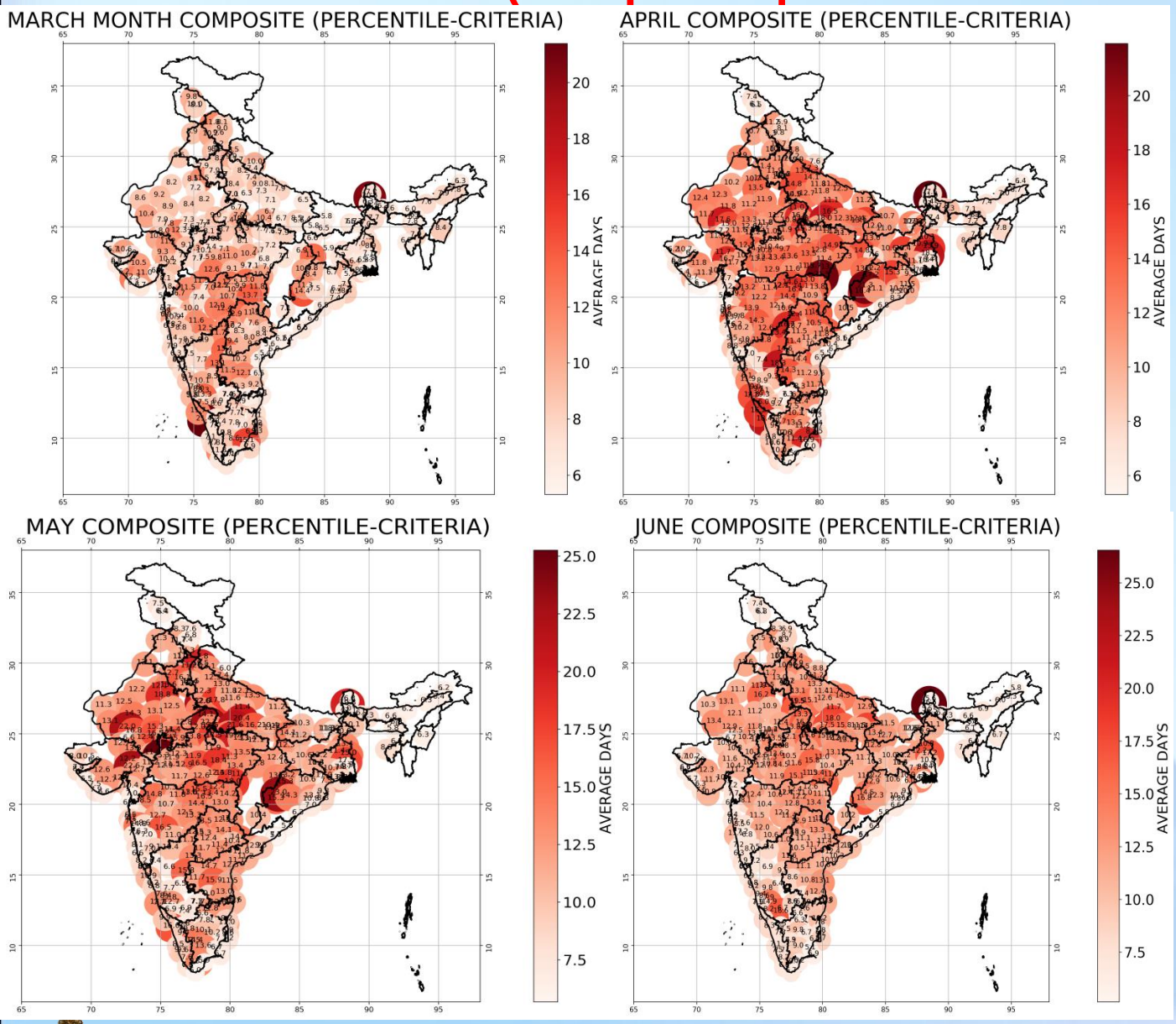






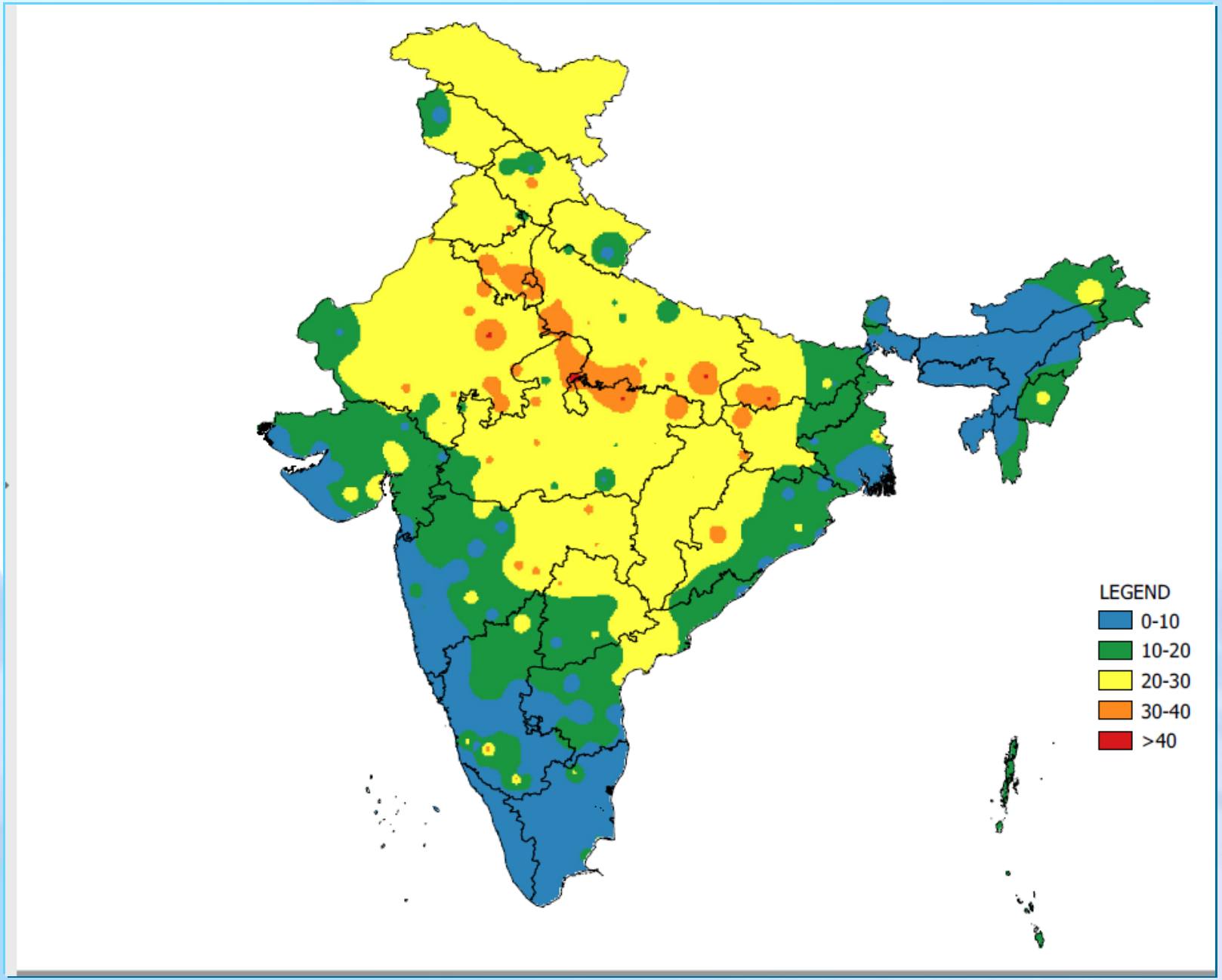
- Maximum number of Severe Hot Day are concentrated in month of April.
- These are largely concentrated around Rajasthan, Madhya Pradesh and Maharashtra in the month of April.
- March and June witnesses the lowest number of very Hot days as compared to April and May.

PERCENTILE BASED (Composite plot for different months)



- Maximum days of heat wave and related activity during month of May over central India.
- Least number of activities during March.
- Total number of heat wave activity reduces in the month of June except over Rajasthan and adjoining regions.

Station wise Heat Wave Hazard Analysis (Experimental)




Thank you