Heat Wave Warnings: Thresholds, Customization, Dissemination and Cooperation in India

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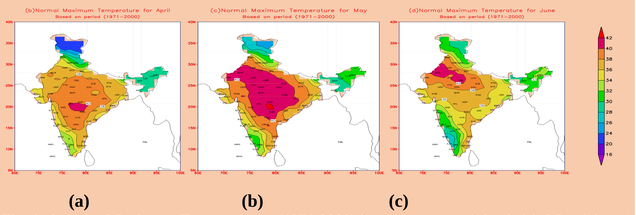
1. Hot Weather Season in India



(a) (b) (c)

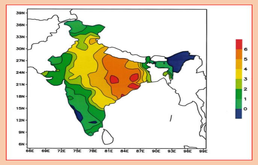
Fig. 1. Average Maximum Temperatures (1971-2000) for the months of April (a), May (b) and June (c)

Temperatures start building up over central parts of the country in the month of April. Area of high temperatures spread to large parts of the country during May. With onset of southwest monsoon around first week of June over southern and eastern parts of the country, the area of high temperature shrinks to northwestern parts of the country.

2. Extension of Hot weather into June:

The hot weather, however, extends into late June in case the onset of monsoon gets delayed.

(a)



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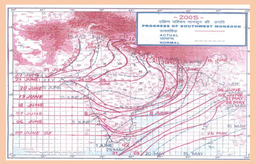


Fig. 2. Maximum Temperature Anomalies for 14-22 June, 2005 (a) showing anomalously high temperatures (by 4-6 Deg. C) over central and eastern parts of India during 3rd week of June caused by late onset of monsoon rains (b)

3. Heat Wave defined in India:

Heat wave in India is Declared only when the actual Max. temp. is 40°C or more in Plains, 30°C or more in Hills, and 37°C or more in the Coastal stations.

a) Based on Departure from Normal

Heat Wave: Departure 4.5°C to 6.4°C
Severe Heat Wave: Departure >6.4°C

b) Based on Actual Maximum Temperature

Heat Wave: Maximum Temperature ≥ 45°C
Severe Heat Wave: Maximum Temperature ≥47°C

c) Criteria for describing Heat Wave for coastal stations

When Max Temp departure from normal is 4.5°C or more

- Heat wave considered only when the actual Maximum Temperature is 40°C or more for Plains, 30°C or more for Hilly regions, and 37°C or more for the Coastal stations.
- To declare heat waves, the criteria should be met at least in 2 stations in a Meteorological sub-division for at least two consecutive days and it will be declared on the second day.

4. Incidences of Heat Waves over India:

Maximum incidence is during May and June. However, some parts of northwest India continue to experience heat waves during July also, particularly in case of delayed onset of monsoon rains. Maximum incidence of heatwaves during the season as a whole is experienced over northwest India, northern plains and east-central parts of the country.

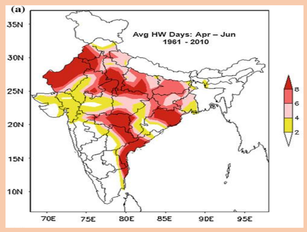


Fig. 4. Average number of Heat Wave days during hot weather season of April to June (Courtesy: Pai et al. DOI 10.1007/978-981-10-2531-0_4)

5. Persistency of heat waves:

Though average number of heat wave days is 6-8 over most parts of the country, continued spells of heat wave lasting for 10-15 days have been realized over most of the heat prone areas in the country. Even severe heat wave period of up to one week have been realized over many parts of the country.

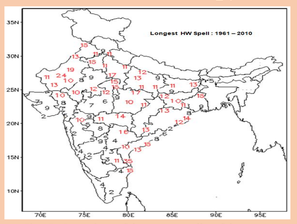


Fig. 5. Duration of longest spells of heat wave and severe heat waves (Courtesy: Pai et al. DOI 10.1007/978-981-10-2531-0_4)

6. Severity of heat waves:

Temperatures in excess of 45 degrees Celsius have been recorded over most of the locations in the country, except over the hilly regions of east & northeast India and over extreme southern parts of the country.

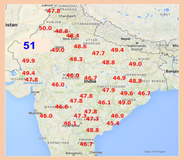


Fig. 6. Highest temperature ever recorded over some selected stations in India

7. Trends in Heat Wave Days: There has been an increasing trend in number of heat wave days over most parts of India during last 50 years. Total number of heat wave days during the season shows an increasing trend. In Figure 7 below, red (green) markers indicate El Nino (La Nina) years. In 9 out of the 14 El Nino years, the Heat Wave days in were more than climatological value (456). **Whereas, in only 3 out of the 12 La Nina years, the Heat Wave days were more than the climatological value.**

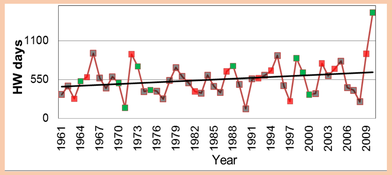


Fig.7. Inter-annual variation in Heat Wave days during hot weather season (April-June) for the period 1961–2010. The El-Nino (La Nina) years are indicated using red (green) marker. (Courtesy: Pai et al. DOI 10.1007/978-981-10-2531-0_4)

8. Temperature Thresholds: Issues

I. Heat Warnings are based only on deviations of Maximum Temperatures from their average values for that time of the year. Neither these are based on impacts nor do these provide any advisory on suggested actions on part of different levels of stakeholders. This required establishing thresholds to provide impact based forecasts for initiating advisories/actions.

In absence of detailed data on heat related deaths, all-cause mortality were related with daily maximum temperatures and thresholds for different levels of warnings (colour Code) were determined.

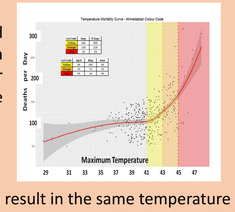


Fig. 8. Temperature-Mortality Curve, Ahmedabad City (courtesy IIPH, Gandhinagar)

II. Change in average values with progress of season result in the same temperature value getting qualified/disqualified to be Heat Wave OR gets qualified to be called Heat Wave in one region but in the other.

➢ *A temperature of 44 C will not qualify for Heat wave for Central India from first week of April to first week of June whereas the same temperature would be called Heat wave in March OR after first week of June.*

➢ *A temperature of 43 C during first week of May shall be termed as heat wave in northwest India BUT not in Central India.*

III. Use of THI and percentile values.

Establishing Thresholds at Chandigarh: A Case Study (April-June)

I. The point of inflexion (THRESHOLD) comes at about 40°C as there is not much difference in daily deaths at all temperatures up to 40°C.

II. This temperature of 40°C may not qualify to be heat wave on certain days.

III. Though the total number of females dying is less at all temperatures, the percent increase in number of deaths at temperatures above 40°C is much higher among the females. **This brings out increased vulnerability of females at higher temperatures.**

➢ ***Such thresholds have been computed for a limited number of cities, primarily for want of Mortality Data.***

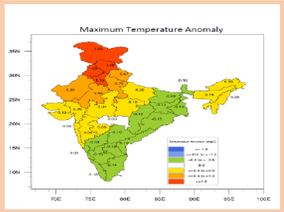
Thresholds: Chandigarh Case Study

Max T (Deg C)	Number of Deaths per Day		
	Male	Female	Total
<35	23.4	13.7	37.1
<40	24.4	13.4	37.8
>40	26.2	15.5	41.7
>42	26.5	15.5	41.9
Increase (%) at Tmax >40 C	7.3	15.7	10.3

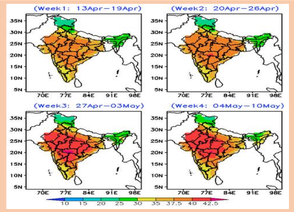
Average Tmax for days having Deaths >1 SD: 39.7 C
Average Tmax for days having Deaths <1 SD: 37.2 C
40°C seems to be the point of inflexion. Though it may not qualify to be heat wave on certain days

9. Heat Wave Outlooks and Warnings and Dissemination

1) **Seasonal Outlooks (twice in the season – 01 March and 01 April):** Meteorological Sun-division wise anomalies of Tmax and Tmin for next 3 months.
2) **Extended Range Forecasts (valid for next 4 weeks, updated once a week):** Spatial maps for bias corrected Tmax/Tmin and their anomalies.
3) **Medium Range Forecasts (valid for 5 days, updated four times a day):** Colour coded warnings for 36 Meteorological sub-divisions and ~ 660 districts.
4) **City Forecasts for ~ 450 cities (valid for 7 days, updated twice a day):** Quantitative forecast for Tmax and Tmin.
5) **Colour Coded warnings for cities where thresholds have been determined.**



(a)



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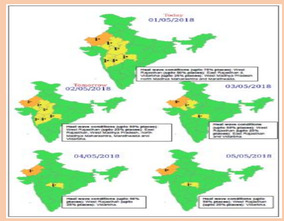

(c)

DATE	FC	Forecast in colour code COLOUR CODE	May-16 ACT	ACTUAL in COLOUR CODE
01	42		43.1	
02	41		43.3	
03	42		42.1	
04	42		42.5	
05	40		39.6	
06	41		40.0	
07	41		39.9	
08	41		40.6	
09	43		42.4	
10	43		42.7	
11	42		43.0	
12	44		43.5	
13	44		44.0	
14	44		44.6	
15	44		44.0	
16	44		44.3	
17	45		43.5	
18	46		45.0	
19	47		46.9	
20	46		48.0	
21	43		44.6	
22	43		44.0	

(d)

Fig. 9.(a) Seasonal outlook for Tmax Anomaly for 3 months April-June, 2018, (b) Extended Range Forecast of Tmax for next 4 weeks, (c) Medium Range Heat Wave Warning (colour coded warnings), and (d) Colour Coded warnings for cities with warning thresholds

Warning Dissemination:

- A dedicated page in IMD website (http://nwp.imd.gov.in/heatwave_fc.php) with following products.
  - ➢ **Operational Products:** Observed & Forecast Temperatures, Daily Heat Wave Bulletin, Extended Range Bulletin, Seasonal Outlook.
  - ➢ **NWP outputs**: Short, Medium & Extended Range Model Guidance (DMO & Bias corrected Tmax and Tmax Anomalies), Weekly Tmax and Tmax Anomalies, Animation.
- Addressed Messages on warnings are sent to different users like Ministries of Home & Health, National, State & District Disaster Management Authorities, Chief Secretaries/Health Secretaries of states, Health Officers at states & districts, Indian Railway, Road transport etc. **Dedicated nodes have been identified in each agency for coordination.**
- **Another effective system of information percolation has been put in place in association with the Indian Medical Association and Indian Red Cross Society who have ground level presence up to sub-district level.**
- **Social Media: Facebook & Twitter handles of IMD and NDMA and WhatsApp Groups.**
- ✓ **Addressed Messages to the State & District Authorities & to the IMA & IRCS have proved very effective.**
- ✓ **Warnings of temperatures exceeding threshold value are provided to the Health/ Municipal Authorities by IMD and NOT to public to avoid panic.**

10. Heat Wave Desk at the National Weather Forecasting Centre, IMD, New Delhi

A special desk works at IMD HQs, New Delhi from dawn to dusk during the hot weather period - 01 April to 30 June performing following tasks.

- Preparation and Monitoring of Temperature related observation and forecast product (both operational and NWP system generated)
- A detailed Temperature/Heat Wave related Information, Observation, Forecast & Warnings bulletin (for next 4 days) issued daily at 1600 hrs IST.
- A special bulletin for TODAY (introduced from this year) is issued to all concerned by 0800 IST for immediate actions, if any.
- A color code system for warning/alert is used.
- A Weekly extended range bulletin for temperatures and heat wave is issued every Thursday with a summary of past week and outlook for next two weeks (for planning).

Green (No action)	Normal Day	Maximum temperatures are near normal
Yellow Alert (Be updated)	Heat Alert	Heat wave conditions at isolated pockets persists on 2 days
Orange Alert (Be prepared)	Severe Heat Alert for the day	(i) Severe heat wave conditions persists for 2 days (ii) Through not severe, but heat wave persists for 4 days or more
Red Alert (Take Action)	Extreme Heat Alert for the day	(i) Severe heat wave persists for more than 2 days. (ii) Total number of heat/severe heat wave days exceeding 6 days.

Fig. 10. Colour Code System for Heat Warning in India

11. National Coordination

Background:

- IMD had been providing heat wave warnings for decades.
- Heat related deaths occurred every year with spikes in years of extended severe heat waves.
- The Ahmedabad Heat Action plan was first such plan to demonstrate that coordinated effort of the Academic Institutions (IIPHG), Active Advocates (NRDC), Action Takers (Ahmadabad Municipal Corporation) and the Operational Service Providers (IMD) could provide effective means of mitigating heat related Mortalities (also morbidity).
- This plan provides a framework for other Indian cities to emulate and help protect their citizens from extreme heat encouraging some more COOPERATING cities in Central, Eastern and Southern parts of the country further cementing the evidence.

Spread of the Movement:

- Evidence generated by the Ahmadabad HAP and active advocacy on part of the IIPHG and NRDC led to a national agency - the National Disaster Management Agency (NDMA) to assume a central role to put a system of Heat Wave Management in India.
- NDMA formulated the first "Guidelines for Preparation of Action Plan - Prevention and Management of Heat-Wave" during 2016 aimed towards providing a framework for implementation, coordination and evaluation of extreme heat response activities in India that reduces the negative impact of extreme heat.

Broad Objectives of the Guidelines

- To alert the populations at risk of heat-related illness in places where extreme heat conditions either exist or are imminent,
- To take appropriate precautions for vulnerable sections at time of high risk.
- To advise on preventive heat management and the administrative action need to be taken by the concerned ministries/departments
- To provide learning experience to develop a plan to deal with Heat Waves in their specific cities/town and thus reduce the negative health impacts of extreme Heat.
- In addition the State Governments should also prepare a comprehensive plan to combat Heat wave.

Key strategies of Implementation of Guidelines:

- Establish Early Warning System and Inter-Agency Coordination
- Capacity building / training programme
- Public Awareness and community outreach
- Collaboration with non government and civil society
- To have formal system of reporting on various aspects (including heat related mortalities) of Heat waves.

12. Feedback and Action Taken Report (ATR) on Heat wave

The NDMA obtains Feedback and Action Taken Report (ATR) on Heat wave from all the heat-prone states at end of each season with following main contents.

A. GENERAL

1. Was State Heat Action Plan was developed? If yes, in which year?
2. Was the Heat Action Plan Updated in 2018?
3. District/city Heat Action Plan developed in this year? (Name of district/city)
4. Contact details of Nodal Agency/Officer (State/district/city)

B. IMPLEMENTATION STRATEGY

1. Whether local thresholds developed? Provide list of cities.
2. When was the stakeholder consultation held? List the mechanisms for consultations and collaboration with stakeholder (State/district level) (Give list of key stakeholders)
3. Was training conducted for heat wave risk reduction and mitigation measures? (Provide complete details)
4. Interagency coordination: Provide list of departments and their roles & responsibilities.

C. KEY INITIATIVES/ BEST PRACTICES

1. What Institutional mechanisms were set up/adopted for Early Warning Dissemination and Communication? (institutes mechanism and other specific instructions)
2. List the activities conducted for risk mitigation of vulnerable groups. (*For example water cooling stations in slums, cool shelters for poor, cooling access in maternity wards, etc.)*
3. Describe other resilience actions taken. *(water conservation, watershed development, planting of trees, access to cooler public places , cool roofs etc.)*
4. What are the Budgetary Provision? (*Under CC/State Disaster Plan etc.)*
5. Please list the top performing cities of your state (with explanation).
6. Please share lessons learnt.
7. Summary of **Data related to Heat wave:** *(Attach separate sheet as per Annexure 5*

Particulars	
Total area affected form heat wave (Sq.km)	
Total No of affected/Illness people (Nos.)	
Total No of casualties recorded (Nos.)	
Total No of casualties verified (final deaths) (Nos)	

8. **Any case study conducted for reducing vulnerability and mortality** (please attach)
9. **Photographs of mitigation measures/activities undertaken by State** (please attach)

Fig. 11. Number of deaths due to Heat Waves in India (data courtesy: NDMA, India)

ACKNOWLEDGEMENTS: WMO, IMD, IIPHG, NRDC, NDMA, Pai et al., 2017