Heat Index:
Possible HAP Action Threshold?

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Since 2009: Working with Partners on Heat-Health in India

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भारत मौसम विज्ञान विभाग INDIA METEOROLOGICAL DEPARTMENT आदित्यात् जायते वृष्टि

Thresholds: their role in HAPs

Different locations use different metrics

Reaching the threshold value triggers response actions to avoid health harms from heat stress

In the absence of health data, often assume 95th to 99th percentile index values are associated with a health response, and use those values for action thresholds

Country	*Threshold*	*Thresholds based on historical mortality*	*Excess mortality forecast*	*Duration of heat event included*	*Seasonality or adaptation included*	*Regionally variable thresholds*	*Human expertise*
Australia (Queensland)	*AT*			2 days		✓	✓
Belarus	*T*						
Belgium	*Tmax/Tmin*/Ozone			3 days			
Canada (Toronto region)	Airmass	✓	✓	✓	✓	✓	✓
Canada (Montreal)	*Tmax/Tmin*			✓			
Canada (all others)	*Humidex*			✓			
China (Hong Kong)	*NET*						
China (Shanghai)	Airmass	✓	✓	✓	✓		✓
France	*Tmax/Tmin*	✓		3 days		✓	✓
Germany	*PT*			2 days	✓	✓	✓
Greece	*Tmax*			✓			
Hungary (Budapest only)	*Tmean*	✓					
Italy	Airmass/*Tapp*	✓	✓	✓	✓	✓	
Republic of Korea	Airmass	✓	✓	✓	✓	✓	✓
Republic of Korea (Seoul*)	Airmass	✓	✓	✓	✓	✓	✓
Latvia	*Tmax*			✓			
Netherlands	*Tmax*			✓			
Poland	*Tmax/Tmin*						
Portugal	*Tmax*	✓	✓	✓		✓	✓
Romania	*ITU*						
Slovenia	Forecaster						✓
Spain	*Tmax/Tmin*	✓				✓	✓
Switzerland	*HI*						
United Kingdom (England and Wales)	*Tmax/Tmin*			✓		✓	
USA (synoptic**)	Airmass	✓	✓	✓	✓	✓	✓
USA (all others)	*HI*			2 days		✓	✓

where:

T	temperature	*HI*	Heat Index
AT or Tapp	apparent temperature	*PT*	perceived temperature
Tmax	maximum temperature	*ET*	equivalent temperature
Tmin	minimum temperature	*ITU*	Temperature Humidity Index
Tmean	mean temperature		

Heat Index: What It Does, How It's Developed

- **Heat Index** (HI) combines air Temperature (T) and Relative Humidity (RH), measures how hot it actually feels:
  - *When RH is high, evaporation rate of perspiration slows, body cools less efficiently & people retain heat

- HI most effective for temperatures >26°C and RH≥ 40%
  - *HI values designed for shady, light wind conditions;
  - *Full sunshine can increase HI values by up to 8°C;
  - *Strong winds, esp. with hot, dry air, are very hazardous

Heat Index Calculation in degrees Celsius

$$HI = -8.78469475556 + 1.61139411(T) + 2.33854883889(RH) + -0.14611605(T*RH) + -0.012308094(T*T) + -0.016424827778(RH*RH) + 0.002211732(T*T*RH) + 0.00072546(T*RH*RH) + -0.000003582(T*T*RH*RH)$$

where

HI = heat index (in degrees Celsius)
T = ambient dry-bulb temperature (in degrees Celsius)
RH = relative humidity (percentage value between 0 and 100)

Source: US National Weather Service, Weather Prediction Center

Table 1: Temperature/ Humidity Index

Relative Humidity %	Temperature °C																
	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
40	27	28	29	30	31	32	34	35	37	39	41	43	46	48	51	54	57
45	27	28	29	30	32	33	35	37	39	41	43	46	49	51	54	57	
50	27	28	30	31	33	35	36	38	41	43	46	49	52	55	58		
55	28	29	30	32	34	36	38	40	43	46	48	52	54	58			
60	28	29	31	33	35	37	40	42	45	48	51	55	59				
65	28	30	32	34	36	39	41	44	48	51	55	59					
70	29	31	33	35	38	40	43	47	50	54	58						
75	29	31	34	36	39	42	46	49	53	58							
80	30	32	35	38	41	44	48	52	57								
85	30	33	36	39	43	47	51	55									
90	31	34	37	41	45	49	54										
95	31	35	38	42	47	51	57										
100	32	36	40	44	49	56											

Caution | **Extreme Caution** | **Danger** | **Extreme Danger**

Source: Calculated °F to °C from NOAA's National Weather Service

Source: NDMA Heat Guidelines (2016)

Heat Index Chart – degrees Celsius and F

NOAA national weather service: heat index

Temperature / Relative humidity	80 °F (27 °C)	82 °F (28 °C)	84 °F (29 °C)	86 °F (30 °C)	88 °F (31 °C)	90 °F (32 °C)	92 °F (33 °C)	94 °F (34 °C)	96 °F (36 °C)	98 °F (37 °C)	100 °F (38 °C)	102 °F (39 °C)	104 °F (40 °C)	106 °F (41 °C)	108 °F (42 °C)	110 °F (43 °C)
40%	80 °F (27 °C)	81 °F (27 °C)	83 °F (28 °C)	85 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	94 °F (34 °C)	97 °F (36 °C)	101 °F (38 °C)	105 °F (41 °C)	109 °F (43 °C)	114 °F (46 °C)	119 °F (48 °C)	124 °F (51 °C)	130 °F (54 °C)	136 °F (58 °C)
45%	80 °F (27 °C)	82 °F (28 °C)	84 °F (29 °C)	87 °F (31 °C)	89 °F (32 °C)	93 °F (34 °C)	96 °F (36 °C)	100 °F (38 °C)	104 °F (40 °C)	109 °F (43 °C)	114 °F (46 °C)	119 °F (48 °C)	124 °F (51 °C)	130 °F (54 °C)	137 °F (58 °C)	
50%	81 °F (27 °C)	83 °F (28 °C)	85 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	95 °F (35 °C)	99 °F (37 °C)	103 °F (39 °C)	108 °F (42 °C)	113 °F (45 °C)	118 °F (48 °C)	124 °F (51 °C)	131 °F (55 °C)	137 °F (58 °C)		
55%	81 °F (27 °C)	84 °F (29 °C)	86 °F (30 °C)	89 °F (32 °C)	93 °F (34 °C)	97 °F (36 °C)	101 °F (38 °C)	106 °F (41 °C)	112 °F (44 °C)	117 °F (47 °C)	124 °F (51 °C)	130 °F (54 °C)	137 °F (58 °C)			
60%	82 °F (28 °C)	84 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	95 °F (35 °C)	100 °F (38 °C)	105 °F (41 °C)	110 °F (43 °C)	116 °F (47 °C)	123 °F (51 °C)	129 °F (54 °C)	137 °F (58 °C)				
65%	82 °F (28 °C)	85 °F (29 °C)	89 °F (32 °C)	93 °F (34 °C)	98 °F (37 °C)	103 °F (39 °C)	108 °F (42 °C)	114 °F (46 °C)	121 °F (49 °C)	128 °F (53 °C)	136 °F (58 °C)					
70%	83 °F (28 °C)	86 °F (30 °C)	90 °F (32 °C)	95 °F (35 °C)	100 °F (38 °C)	105 °F (41 °C)	112 °F (44 °C)	119 °F (48 °C)	126 °F (52 °C)	134 °F (57 °C)						
75%	84 °F (29 °C)	88 °F (31 °C)	92 °F (33 °C)	97 °F (36 °C)	103 °F (39 °C)	109 °F (43 °C)	116 °F (47 °C)	124 °F (51 °C)	132 °F (56 °C)							
80%	84 °F (29 °C)	89 °F (32 °C)	94 °F (34 °C)	100 °F (38 °C)	106 °F (41 °C)	113 °F (45 °C)	121 °F (49 °C)	129 °F (54 °C)								
85%	85 °F (29 °C)	90 °F (32 °C)	96 °F (36 °C)	102 °F (39 °C)	110 °F (43 °C)	117 °F (47 °C)	126 °F (52 °C)	135 °F (57 °C)								
90%	86 °F (30 °C)	91 °F (33 °C)	98 °F (37 °C)	105 °F (41 °C)	113 °F (45 °C)	122 °F (50 °C)	131 °F (55 °C)									
95%	86 °F (30 °C)	93 °F (34 °C)	100 °F (38 °C)	108 °F (42 °C)	117 °F (47 °C)	127 °F (53 °C)										
100%	87 °F (31 °C)	95 °F (35 °C)	103 °F (39 °C)	112 °F (44 °C)	121 °F (49 °C)	132 °F (56 °C)										

Key to colors: Caution | Extreme caution | Danger | Extreme danger

For example, if the air temperature is 96 °F (36 °C) and the relative humidity is 65%, the heat index is 121 °F / 49 °C.

Is a Heat Index Appropriate as a HAP Threshold?

- Do cities have access to Past, Present, & Future local maximum Heat Index data, to calculate a possible Heat Index threshold value?
- Does IMD already provide Heat Index information for cities, in a user-friendly format?
- What if coastal cities applied IMD's Heat Wave definition, i.e. Heat Wave declared on days ≥ 40°C
- What would it take to develop a NEW Heat Index for India? Is it needed?

What could be an effective user format?
("dashboard")

How can **both the meteorological data *producer* community and the *user* community be engaged**, to develop effective approaches to setting humidity-inclusive HAP thresholds?

Suggestions & Options

Determine what regions & which cities have been asking for a Heat Index approach

Evaluate heat-health evidence regarding which cities experience harmful effects of humidity, in addition to heat

Do cities in India have access to past & present data needed to calculate the maximum daily Heat Index threshold? Or future forecasts of maximum daily Heat Index?

Is a Heat Index that's unique to India needed?

Engage the meteorology information producers *and* users to develop temperature + humidity output formats

Heat Index - - Next Steps

Provide a forum for discussion of:

- Whether temperature-humidity metrics like HI could be more health-protective HAP thresholds in more humid Indian cities
- Whether existing Heat Index data (archived and forecasted) is already available to cities for use as municipal HAP thresholds
- What form might an effective presentation of Heat Index data take, to be useful to cities in HAP threshold-setting
- Whether a Heat Index calculation unique to India is needed

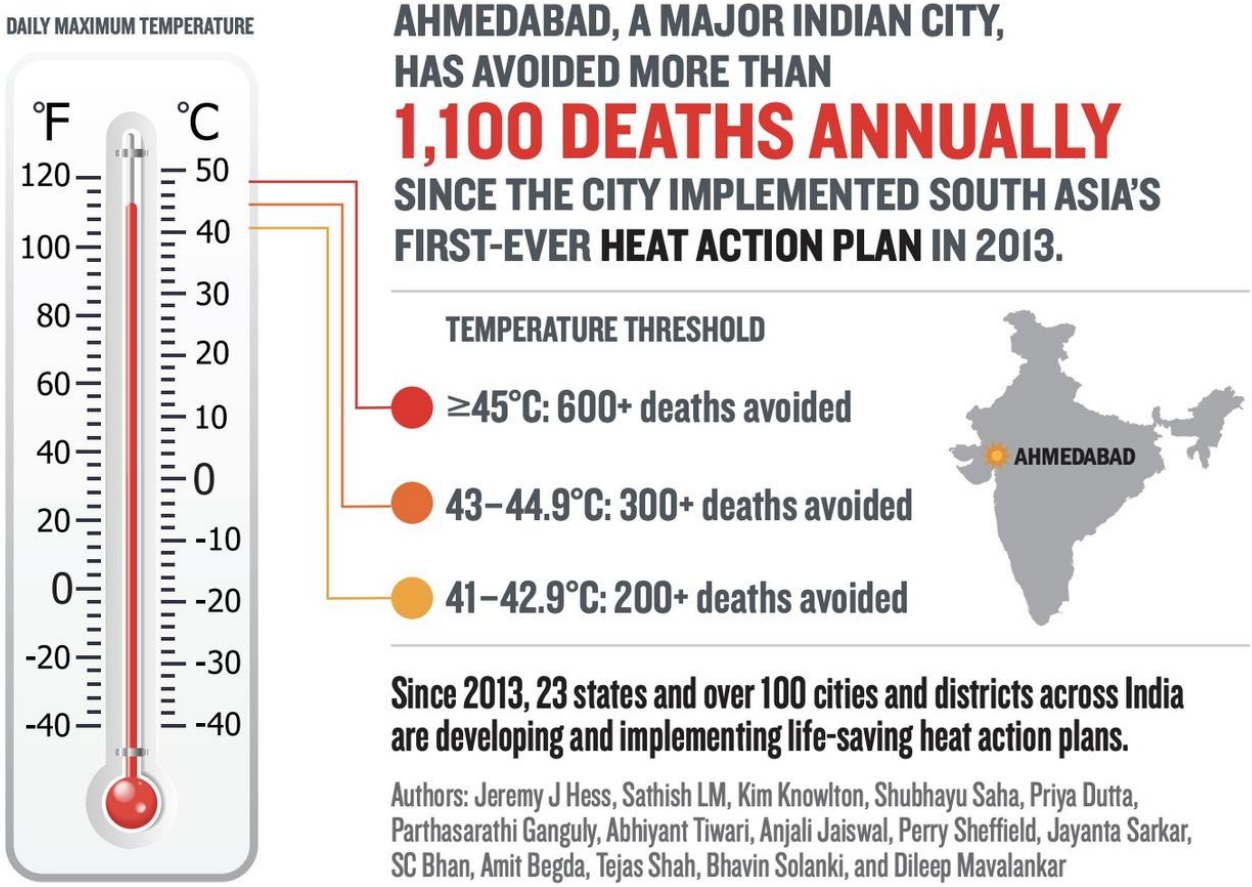
Do Heat Action Plans make a difference?

Is heat vulnerability reduced after launching a HAP?

We evaluated summer deaths ***before*** & ***after*** the 2013 HAP launch.

We found that:

- Adaptations to reduce people's vulnerability to extreme heat **save lives**.
- Mortality rates on days >40°C (104°F) show **5% decrease post-HAP** (2014-2015), relative to pre-HAP (2007-2010).
- Mortality rates on hottest days >45°C (113°F) showed a 27% decrease post-HAP.



Hess JJ, et al. 2018. Building resilience to climate change: pilot evaluation of the impact of India's first Heat Activation Plan on all-cause mortality. Journal of Environmental and Public Health, vol. 2018, Article ID 7973519 (8 pp.). https://doi.org/10.1155/2018/7975519.

Background on Heat Index

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Heat Index Calculation

NWS Weather Prediction Center, “The Heat Index Equation”:

https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml

NWS on “Heat Index Forecasts”:

https://www.weather.gov/bgm/heatindexforecasts

Thank you

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