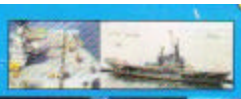
May 2009
Rs. 20/-

Science Reporter

INS Viraat Pg 29



Feeling Hot
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Targeting Pain !

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MANJU MOHAN & SHWETA BHATI

Are You Comfortable Weather-Wise?

Every place has distinct weather conditions in different months of the year. The degree of comfort that you feel depends on a number of varying factors.

THE dreaded summer is fast approaching and people in Delhi can already feel the heat. Coolers are being readied and air conditioners being serviced. In fact, the whole of north India is gearing up for the dust and heat, and sweat and heat waves that follow in the coming months.

Weather plays a vital role in our daily lives. The course of our daily activities depends much upon weather. While visiting any new place, the first information we seek out is about its weather. Temperature is perhaps the most important meteorological parameter from the point of view of human comfort. However, our response to ambient temperature depends on many other meteorological parameters as well.

Most importantly, wind and relative humidity play a significant role in determining how cool or warm it might actually feel at a given temperature level. This is because the rate at which heat is dissipated from the human body through the skin determines how warm we feel in the summer season or how cold we feel in the winters. In other words, there can be a difference between the actual ambient temperature and one that the human body feels. It is important to be aware of this 'apparent temperature' as it often aids in scheduling outdoor activities and deciding optimum temperature levels at workplaces. Consequently, air conditioning requirements in cities and towns also depend on this parameter.

Heat Index and Wind Chill are two important indices for hot and cold

Months from May to September fare worse recording only 5% of hours in comfortable category, which can be attributed to the characteristic high temperature-high humidity conditions of this period in Delhi.

Heat Index Chart

Relative Humidity (%) \ Temperature (°F)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Wind Chill Chart

Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes | 10 minutes | 5 minutes

Wind Chill (°F)=35.74+0.6215T-35.75($V^{0.16}$)+0.4275T($V^{0.16}$)

Where, T=Air Temperature (°F) V=Wind Speed (mph)

Fig.1. Heat Index and Wind Chill Estimation Chart of National Weather Service, US

weathers, respectively, that act as indicators for this apparent temperature. Heat Index can be considered as a contribution of high temperature accompanied with humidity and how it affects the body's ability to cool itself, which in effect governs our ability to cope up with the severity of the summer season and intermittent monsoon periods. Wind Chill, on the other hand, combines the effects of high wind speed with low temperature conditions, enhancing rapid heat loss from the skin, which in turn governs how severe the winter season would appear to us.

Heat Index

The metabolic processes in the human body generate excess heat, which needs to be transmitted away to maintain internal thermal balance. This process mainly takes place through the skin. Up to a temperature of about 24°C, the excess heat can simply be lost from the skin through radiation and thus temperatures around or below this level are usually comfortable. As the ambient temperature increases more than 24°C, the surface area of the skin becomes insufficient for heat loss by simply radiation, and thus sweat glands of the body are activated.

Sweating makes heat transfer from the body to its surroundings feasible through evaporative cooling. On a hot, dry day, sweat evaporates quickly and cools the skin. However, as the moisture levels in surrounding air increase, the process of evaporation is retarded.

The winter season in Delhi starts in late November and ends early February. This period is dominated by cold, dry air and ground-based inversion with low wind conditions.

Table 1. Classification of Comfort Index

Scale	Condition
Severe Danger	Wind chill < -35 °C
Extreme Cold	-35 °C < Wind chill < -20 °C
Uncomfortably Cold	-20 °C < Wind chill < 0 °C
Cool	0 °C < Temperature < 15 °C
Comfortable	15 °C < Temperature < 25 °C
Warm	25 °C < Temperature < 32 °C
Uncomfortably Hot	Temperature > 32 °C and Heat Index < 38 °C
Severe Danger	Heat Index > 38 °C

Source: http://www.saskschools.ca/~ghuczek/definitioncomfortindex.htm?

In the months of July and August 2007, the highest instances were observed where apparent temperature was higher than actual temperature. So these months are most affected by heat index conditions.

Thus, heat is removed from the body at a lower rate causing it to retain more heat than it would in dry air making one feel warmer for a given temperature in humid conditions as compared to dry weather. The heat index (HI) is the index that combines air temperature and relative humidity in an attempt to determine the human-perceived equivalent temperature, that is, how hot it feels, termed often as apparent air temperature.

The expression for estimation of heat index is derived from work carried out by Steadman in 1979, and this was subsequently improved upon by meteorologists. The expression was determined keeping in consideration the response of human skin to varied temperature and humidity levels. Naturally, several assumptions are used in calculating heat index.

The heat index is calculated for a typical situation in which a person who is 5 feet 7 inches tall and weighs 147 pounds (67 kg) walks in shade at about 3.1 miles per hour (~5 km/hr) in a light breeze of 6 mph (~9.7 km/h), wearing long pants and a short-sleeved shirt. A change in any of these factors will result in a different heat index for a different individual. Thus, different individuals at the same time may perceive the weather differently. Hence, reported heat index values should not be taken as a strict benchmark for deciding one's own response to weather.

For easy interpretation of heat index, a chart has been prepared by the National Weather Service, US to calculate the approximate heat index for a given temperature and humidity (Figure 1). Depending upon possible heat-related disorders that a person might develop on exposure to an environment with a particular heat index, health concern based categories have been assigned to a range of heat index values. These are Comfortable (< 27°C), Caution ((27-32°C), Extreme Caution (32-41°C), Danger (41-54°C) and Extreme Danger (> 54°C). Table 2 lists the possible disorders for each category.

Wind Chill

Just like sweat evaporation is rapid in hot dry weather and aids in rapid cooling of skin, moving air also removes heat from the body quickly. This effect is, however, more pronounced and significant in colder weather. The bare human skin is covered by a thin boundary layer of air which acts as insulator in perfectly calm conditions. This causes the skin temperature to be slightly higher than that of the ambient air temperature. Moving air blows away this layer reducing its thickness and thereby removing heat from the body more effectively than still air. The skin temperature then gets closer to the air temperature.

In windy conditions, a person might feel colder than what he would actually feel at the same temperature in calm conditions. This apparent temperature is due to Wind Chill Factor. The Wind Chill Temperature (WCT) index is the measure of the relationship between temperature and cooling effect of wind. This temperature represents the 'feel' of a wind on exposed human skin in terms of an equivalent temperature in still air. Undoubtedly, wind chill can make a fairly moderate winter day feel like a much colder one.

In the year 2001, the National Weather Service implemented an updated WCT index. The improved expression for wind chill was determined by iterating a model of skin temperature under various wind speeds and temperatures. The model used standard engineering correlations of wind speed and heat transfer rate. Heat transfer was calculated for a bare face in wind, facing the wind, while walking into it at 3 mph (1.37 m/s). The model corrected the officially measured wind speed to the wind speed at face height, assuming the person is in an open field.

Wind chill temperature is only defined for temperatures at or below 50 degrees F (10°C) and wind speeds above 3 mph (4.8 kmph). Bright sunshine may increase the wind chill temperature by 10 to 18°C. Table 2 lists the classification of Wind Chill temperature levels in terms of frostbite times on exposure.

Weather of Delhi

Delhi is located at latitude 28° 38' 17" N and longitude 77° 15' 51" E with an altitude of 215 m above sea level. The climate is mainly influenced by its inland position and the prevalence of continental air during a major part of the year and has extreme climatic conditions. Delhi has three distinct seasons namely summer, monsoon and winter.

The summer season (April, May and June) is governed by high temperature and hot, high speed winds. The monsoon (July, August and September) is dominated by rains and high humidity levels in air. The winter season starts in late November and ends early February. This period is dominated by cold, dry air and ground-based inversion with low wind conditions. The months of February and

Table 2. Health concerns related to different Heat Indices and Wind Chill temperatures

Heat Index (°C)		Possible Heat Disorders
> 54	Extreme Danger	Heat stroke or sunstroke likely.
41 - 54	Danger	Sunstroke, muscle cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
32 - 41	Extreme Caution	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
27 - 32	Caution	Fatigue possible with prolonged exposure and/or physical activity
Wind Chill Temperature (°C)	**Risk of Frostbite**	**Health Concern**
>0	Frostbite Unlikely	Discomfort
0 to -9	Low	Slight increase in discomfort
-10 to -27	Low	Uncomfortable- Risk of hypothermia if outside for long periods without adequate protection
-28 to -39	Increasing risk: exposed skin can freeze in 10 to 30 minutes	Risk of hypothermia if outside for long periods without adequate protection
-40 to -47	High risk: exposed skin can freeze in 5 to 10 minutes*	Risk of hypothermia if outside for long periods without adequate protection
-48 to -54	High risk: exposed skin can freeze in 2 to 5 minutes*	Serious risk of hypothermia if outside for long periods
-55 and colder	High risk: exposed skin can freeze in less than 2 minutes	DANGER!- Outdoor conditions are hazardous

Sources: http://www.weather.gov/os/heat/index.shtm, http://www.msc.ec.gc.ca/education/windchill/windchill_threshold_chart_e.cfm

March are also referred to as spring period and the months of October and November are sometimes designated as post-monsoon months.

We carried out a study to estimate Heat Index and Wind Chill for a period of about two and a half years (April 2006-October 2008) in Delhi. The meteorological data was obtained from the WatchDog Weather Station (Model 550) installed at the Indian Institute of Technology, Delhi. WatchDog Weather Station features a built-in data logger that stores measurements in memory at user-defined intervals that can be transferred to the computer. Measurement intervals can be selected from 1 to 120 minutes. Model 550 can be used for wind speed, wind direction, temperature and humidity measurements with accuracy of ±5 %, ±7°, ±0.7°C and ±3% respectively.

The data was tabulated in the form of hourly averages. As per the formula for calculation of heat index and feeling for uncomfortable weather, only those hours were considered for computation

Temperature is perhaps the most important meteorological parameter from the point of view of human comfort. However, our response to ambient temperature depends on many other meteorological parameters as well.

of heat index in which the temperature was above 26°C and relative humidity was at least 40%, excluding events of precipitation. Hours affected by heat index were compared month-wise as well as year-wise for a given month. Even though heat index computation is relevant in extreme summer months, data for the months of March to October of all years was considered to examine the effect to which moisture levels could increase actual ambient temperature even in comparatively cooler months.

Wind chill temperatures in winter season (November-February) were also calculated for those hours where temperature was below 10°C and wind speed was above 3 mph (4.8 kmph). Month-wise and year-wise comparisons were done along the lines of data for heat index. The following points were noted:

- The impact of moisture levels on apparent temperature is quite prominent from the fact that the months of June, July, August and September, which are pre-monsoon, monsoon and post-monsoon months, experience maximum hours where heat index introduces increase in actual temperature. In the months of July and August 2007, the highest instances were observed where apparent temperature was higher than actual temperature. So these months are most affected by heat index conditions.
- The months of March, April and October of all the years under study do not experience high temperature-high humidity conditions and thus are not much affected by Heat Index.