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Letters to the Editor

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HEAT WAVE CONDITIONS DURING MARCH TO JUNE FOR THE YEARS 1972, 1979 AND 1987 AND THEIR COMPARISON WITH YEARS 1990-1995

1. During the period March to June, when the normal maximum temperature is generally high over the Indian sub-continent, any further rise in temperature becomes a matter of concern to the people in all walks of life. If the hot spell is prolonged, it creates shortage of water in some areas. For agriculturists it leads to condition for drought. This disastrous phenomenon gives physiological strain also which some times claims heavy toll of live stock and human beings. There is no fixed periodicity or maximum extent of spread associated with each hot spell. However, during each hot weather season there are 2 or 3 occasions when the hot spell appears or disappears after a few days. This has probably led to the idea of calling them as heat waves.

1.1. Moreover, wave generally signifies movement and also short duration of the phenomenon. India Meteorological Department (IMD) has adopted criteria for declaring heat waves in which the actual maximum temperature do not figure in any direct manner in the description of a heat wave. It is only the departure from normal that defines heat wave conditions.

2. Heat wave conditions data is taken from Indian Daily Weather Record (IDWR) and weather charts from the Office of Deputy Director General of Meteorology (Weather Forecasting), Pune. India Meteorological Department (IMD) has introduced a revised criteria for declaring heat wave conditions *w.e.f.* 1 Jan 1989 and the same is used here. A different criteria was used earlier to 1 Jan 1989. The earlier studies by Bedekar *et al.*(1974) were based on these criteria. Therefore, the findings based on earlier studies cannot be used subsequently. There are many departures in the intensity, frequency and duration over different meteorological subdivisions. This has necessitated the study of heat wave conditions following the new criteria which would help the forecaster.

3. The days of heat waves, following the criteria of IMD were found for the months of March to June for the years 1990 - 1995 and these were compared with the phenomenal drought years of 1987, 1979 and 1972.

3.1. Fig. 1 (a) gives the number of days of heat waves affecting the meteorological sub-divisions for the years 1990 - 1995, 1987, 1979 and 1972. It is seen from this figure that heat wave conditions prevailed more than 80 days over Rajasthan, Madhya Pradesh and Vidarbha, maximum being 108 days in west Rajasthan. Heat wave conditions also prevailed for more than 40 days in Rajasthan, Madhya Pradesh, Vidarbha, Gujarat state, Orissa, Uttar Pradesh, Haryana, Punjab, coastal Andhra Pradesh and Telangana.

3.2. In Fig.1 (b) number of days of heat waves in a meteorological sub-division for the month of June is given. It is seen that more than 40 days of heat wave occurred in Rajasthan, Haryana, plains of Uttar Pradesh, Madhya Pradesh and Vidarbha and more than 20 days heat waves in June, occurred in Rajasthan, Haryana, Punjab, plains of Uttar Pradesh, Madhya Pradesh, Bihar plains, Orissa, Telangana, Vidarbha and Marathwada.

3.3. In Fig. 1(c) we see that west Rajasthan had 44 days of heat wave in May. More than 20 days of heat wave prevailed in May over Rajasthan, Madhya Pradesh, Vidarbha and Andhra Pradesh.

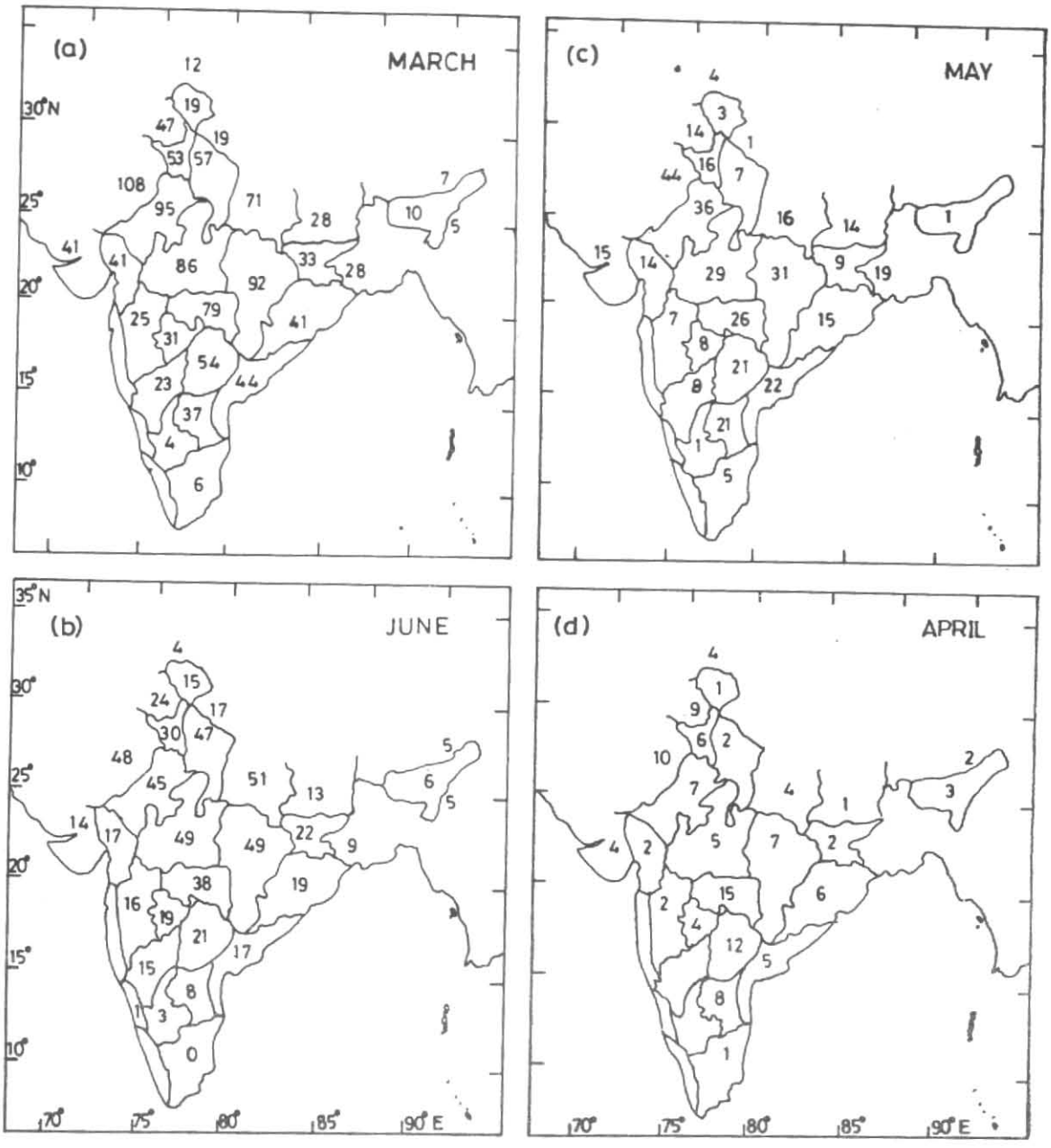
3.4. In Fig. 1(d) in April, Vidarbha, west Rajasthan and Telangana had more than 10 days heat wave. Further Punjab, Haryana, east Rajasthan, Madhya Pradesh, Orissa, coastal Andhra Pradesh and Telangana had more than 5 days of heat wave.

3.5. Thus we may conclude that the maximum frequency of heat wave is along a belt from Rajasthan to Andhra Pradesh across Madhya Pradesh and Vidarbha for the months of March, April, May and June and also for the months of March to June taken together.

3.6. Table 1, gives year wise heat wave conditions for the months of March to June. It also gives the number of meteorological sub-divisions affected by heat wave, number of days of heat wave and the average heat waves over the sub-division for all the years under consideration. Table 1 also gives frequency of heat waves occurring between 5 and 10 days, 11 and 15 days, 16 and 20 days.

3.7. Table 2 shows the number of days of heat waves in each month from March to June for all the meteorological sub-divisions year wise.

3.8. In March, heat wave affected only in 1991 and 1994, 41 days of heat wave prevailed in 14 meteorological sub-divisions.



Figs. 1 (a-d). Number of heatwave days 1990-95, 1972-79 and 1987 during March, April, May and June

3.9. In April, the number of days of heat wave and number of meteorological sub-divisions affected by heat wave increased significantly. There were 55 meteorological sub-divisions and 122 days of heat wave. However, there were no heat waves in 1972 and 1987 which were drought years.

3.10. In May, number of heat wave days and number of meteorological sub-divisions increased compared to April. There were 105 meteorological sub-divisions and 410 days of heat waves.

3.11. In June, there were 126 meteorological sub-divisions and 628 heat wave days. We may note the following :

(*i*) May and June are the months (though June is greater than May) when maximum number of meteorological sub-divisions are affected with maximum number of heat waves.

(*ii*) Duration of heat wave is of 5 days or less in all the months.

(*iii*) About 7.6% (31.1× 100 ÷ 410) heat waves have duration, between 5 and 10 days in May and about 6% (37.4 ×100 ÷ 62.8) heat waves duration 5 and 10 in June.

TABLE 1
Details of heat wave conditions in March, April, May and June

Year	Number of meteorological sub-division affected	Total number of days of heat waves	Average number of heat waves over sub-division	Heat wave affecting meteorological sub-divisions between		
				5-10 days	11-15 days	16-20 days
1972	15	126	8.4	9	3	0
1979	22	83	3.7	5	0	0
1987	16	96	6.0	6	1	1
1990	16	58	3.6	3	1	0
1991	16	124	7.8	10	0	1
1992	20	67	3.4	3	0	0
1993	22	161	7.3	10	2	0
1994	26	204	7.8	14	3	0
1995	27	282	10.4	10	11	1

TABLE 2
Number of days of heat waves in each month for all meteorological sub-divisions

Year	Number of meteorological sub-division	Total number of heat wave days	Average days of heat wave per meteorological sub- division	Heat wave affecting meteorological sub-divisions between the days		
				5-10 days	11-15 days	16-20 days
			March			
1991	4	7	1.7	0	0	0
1994	10	34	3.4	5	0	0
Total	14	41	2.6	5	0	0
			April			
1979	8	19	2.4	0	0	0
1990	16	50	3.1	3	1	0
1991	5	7	1.4	0	0	0
1992	9	12	1.3	0	0	0
1993	13	29	2.2	0	0	0
1994	1	1	1.0	0	0	0
1995	3	4	1.3	0	0	0
Total	55	122	12.7	3	1	0
			May			
1972	5	25	5.0	2	0	0
1979	5	12	2.4	0	0	0
1987	7	20	2.9	2	0	0
1990	5	8	1.6	0	0	0
1991	13	68	5.2	5	0	1
1992	9	13	1.4	0	0	0
1993	21	89	4.2	6	2	0
1994	23	104	4.2	5	2	0
1995	17	71	4.2	3	2	0
Total	105	410	31.1	23	6	1
			June			
1972	15	101	6.7	7	3	0
1979	17	52	3.0	5	0	0
1987	15	76	5.0	4	1	1
1990	0	0	0	0	0	0
1991	10	42	4.2	5	0	0
1992	13	42	3.2	3	0	0
1993	12	43	3.6	4	0	0
1994	19	65	3.4	4	1	0
1995	25	207	8.3	7	9	1
Total	126	628	37.4	39	14	2

TABLE 3

Rainfall in terms of meteorological sub-divisions onset dates of southwest monsoon over Kerala and number of days of heat waves

Year	Pre-monsoon		Monsoon		Post monsoon		Winter		Onset rate over Kerala	No. of heat wave days	No. of heat wave days in May	No. of heat wave days in June	%
	E+N	D+S	E+N	D+S	E+N	D+S	E+N	D+S					
1972	11	24	15	20	17	18	17	18	18 June	126	25	101	80
1979	14	21	17	18	22	13	26	9	11 June	83	12	52	62
1987	20	15	14	21	23	11	14	21	2 June	96	20	76	79
1990	30	5	32	3	29	6	19	16	19 June	58	50	8	14
1991	19	16	28	7	11	24	10	25	1 June	124	68	42	34
1992	8	27	30	5	15	20	11	14	5 June	67	13	42	62
1993	23	12	23	12	20	15	9	26	28 May	161	89	43	27
1994	19	6	27	8	19	16	21	4	28 May	204	104	65	32
1995	19	16	23	2	19	16	26	9	5 June	282	71	207	73

4. *Frequency* : Maximum number of heat waves and maximum number of meteorological sub-divisions affected by heat waves are in the month of May and June. A belt from west Rajasthan to coastal Andhra Pradesh is a region more susceptible for occurrence of heat wave as mentioned earlier. Duration of heat waves on more than 90% of the occasion is 5 days or less. However, about 12% of them in May and June will have duration of 5 to 10 days. Duration more than 10 days are very rare.

4.1. *Extent of heat wave* : In more than 90% of the cases heat wave occurs in Rajasthan and spreads southeastwards to Andhra Pradesh and east-southeastwards to Bihar. There are a few cases when the heat waves from over Vidarbha and neighbourhood. Duration of such heat wave is generally 2 to 3 days. In other words, advection of heat wave is a phenomenon which takes place in about 80% of the cases. Whereas, *in situ* development of heat waves occur hardly in less than 20% of cases.

4.2. *Synoptic features favouring heat waves* : Dry continental air prevails throughout the hot weather season and gives rise to clear weather north of 20° N. As there is no possibility of moisture incursion into northwest India, it remains practically hot with clear skies which provides maximum insolation. The warmer air is then advected to the east and southeast of that region as per the seasonal westerly/ northwesterly flow there. This type of flow pattern is generally used for formation and advection of heat waves.

4.3. The above synoptic features are generally associated with the formation and advection of heat wave conditions over India. It may be emphasized that advection of heat wave conditions can be predicted more easily than the initial formation of heat wave conditions.

4.4. A study of correlation between the thickness of the layer between 1000 and 500 hPa level to the severe heat wave is done. Mcqueen and Cadesman (1957) have shown the correlation of heat waves with thickness of airmass between 1000 hPa and 500 hPa level. This gives an advance indication of the approach and decay of heat waves. Height changes between 1000 hPa and 500 hPa are prepared for all above cases. It is found that increased thickness, resulting from the warming of the layer between 1000 hPa and 500 hPa is advected to the regions where the severe heat waves are experienced. The prevailing wind anomaly northwesterly to westerly to the north of 20°N will help the transport of warm air in the lower troposphere and cause heat wave.

4.5. *Heat wave versus rainfall over India and onset of southwest monsoon* : Rainfall over India during pre-monsoon, monsoon, post monsoon and winter season over 35 meteorological sub-division in terms of E - excess, (+20% and above) N - normal (+ / - 19%) D - deficient (-20% - 59%) and S - scanty (less than 60%) are given in Table 3. In addition onset dates of monsoon over Kerala, number of heat wave days throughout the year, in May and June are also given in Table 3.

4.6. 1972, 1979 and 1987 are drought years. In these years out of 35 meteorological sub-divisions, excess plus normal rainfall was in 15 meteorological sub-divisions in 1972, 17 meteorological sub-divisions in 79 and 14 meteorological sub-division in 1987. Number of heat wave days in March, April and May were 126 in 1972, 83 in 1979 and 96 in 1987. Monsoon set over Kerala on 18 June in 1972, 11 June in 1979 and 2 June in 1987.

4.7. In normal monsoon years 1991, 1992 and 1995, the onset dates of monsoon over Kerala was 1st June, 5th June

and 8th June respectively and the corresponding number of heat wave days were 12, 67 and 282 respectively.

4.8. Thus late onset of monsoon has no relation with more number of heat wave days and also with normal monsoon or below normal monsoon years. In other words in drought years or in good monsoon years there is no relation with more or less number of heat wave days.

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