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# A study on variation of maximum temperature over Bhopal during last decade

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**सार** — ग्रीष्म कालीन चार माह मार्च, अप्रैल, मई व जून का वर्ष 1977 से 1987 तक भोपाल के अधिकतम तापमान का अध्ययन किया गया है। अधिकतम तापमान के एक दिन पहले के "तापमान से परिवर्तन", "सामान्य से विचलन" की भी गणना की गई है। प्रत्येक माह की एक या अधिक दिन की तापमान में लगातार "गिरावट," "वृद्धि" या "परिवर्तन नहीं" की श्रेणी का अलग से अध्ययन किया गया है। और यह पाया गया है कि "थोड़ा परिवर्तन" व "परिवर्तन नहीं" दोनों श्रेणी को मिलाकर यह कुल का 65 प्र. श. होता है। इन सभी महीनों में जैसे-जैसे परिमाण बढ़ता है आवृति धीरे-धीरे कम होती है। यह भी देखा गया है कि दक्षिणपूर्व मध्यप्रदेश पर निचले स्तरों पर जब भी कोई चक्रीय वायु होती है तब भोपाल के अधिकतम तापमान में 4° से. तक की वृद्धि होती है तथा इसके उत्तर दिशा की ओर बढ़ने पर यह बढ़ोतरी 6° से. तक होती है। सामान्य से विचलन के विषय में यह पाया गया है कि "लगभग सामान्य" से "सामान्य से अधिक" कुल विचलन का 50 प्र.श. होता है। "सामान्य से कम" और "परिवर्तन नहीं" 30 प्र. श. तथा शेष पांचों समूह मिलकर 20 प्र.श. होता है।

ABSTRACT. Daily maximum temperatures of Bhopal for four summer months, *i.e.*, March-June have been studied for the years 1977 to 1987. From daily values of maximum temperatures, changes from the previous day value were calculated. Daily departures were also calculated. Depending upon their ranges, the changes are classified as per the standard meteorological convention. The frequency of occurrence of each category has been worked out for these months. Similar anaysis has been done for departures also. Percentage number of cases in the month where the temperature either continuously falls, rises or does not change for more than one day have been documented separately. Results indicate that in case of changes, 'Little change' together with 'No change' pre-dominates and accounts for 65% of the cases. It is observed that for all the months there is a gradual fall in the percentage frequency as the magnitude of variation of maximum temperature increases.

## 1. Introduction

Forecasting the daily changes in the maximum temperatures during summer months is of immense importance as the general public is greatly concerned with these changes. The climatological aspects of heat waves over India has been studied by Raghavan (1966) based on the data from 1911 to 1961. Bedekar *et al.* (1974) made further study of heat waves taking into consideration data for later years 1962 to 1967 also. It is observed that the number of cases of heat waves over Bhopal are very few, except in the month of June but the need to issue the local forecast for variation in maximum temperature during summer is a daily necessity. The best way to improve the accuracy of local forecast for the changes in maximum temperature is to study the behaviour of the changes of the parameter over the station with all available data. With this aim in view, maximum temperature data of the station for the last eleven years for the summer months were studied and changes were classified under different scales of magnitude. For cases, where changes were more than 4°C, an attempt has been made to explain the changes with the prevalent synoptic situations on those days.

## 2. Analysis of data

(*i*) Daily maximum temperature data of Bhopal was collected for the period 1977 to 1987 for four summer months of March-June. Changes in the maximum temperatures were calculated with respect to the previous day's value and were tabulated. These changes were then classified according to their magnitudes based on the standard meteorological convention given by the India Met. Dep. (1971).

From the daily maximum values of temperatures, changes were calculated and the number of cases of change of a particular magnitude for a particular month for the period 1977-87 were counted and the analysis was repeated for the months of March-June. From the total number of cases, percentage of cases under 'No change', 'Little change', 'Rise', 'Fall', 'Appreciable rise', 'Appreciable fall', 'Markedly rise', 'Markedly fall' were counted and are presented in Table 1.

Individual cases, where temperature changes 4°C or more in magnitude, were identified. Synoptic situations on these days were examined for offering the proper explanation.

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TABLE 1

**Percentage variation of changes of maximum temperature over Bhopal under different magnitude scales for March to June**

| Month | Type of changes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | No change | Little change (±1) | Rise (+2 to +3) | Appr. rise (+4 to +5) | Markedly rise (+6 to +7) | Fall (—2 to —3) | Appr. fall (—4 to —5) | Markedly fall (—6 to —7) |
| Mar | 21.4 | 38.8 | 19.6 | 2.7 | — | 13.0 | 4.1 | 0.3 |
| Apr | 33.6 | 41.2 | 13.3 | 1.2 | — | 8.2 | 1.8 | 0.6 |
| May | 32.5 | 46.1 | 9.2 | 0.9 | — | 10.7 | 0.6 | — |
| Jun | 25.9 | 38.2 | 13.1 | 1.5 | 0.9 | 12.8 | 4.3 | 3.1 |

TABLE 2

**Parcentage number of cases of departure of maximum temperature of varying steps over Bhopal for March to June**

| Month | Types of changes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No change (0) | Nearly normal (±1) | Above normal (+2 to +3) | Appr. above normal (+4 to +5) | Markedly above normal (+6 to +7) | Below normal (—2 to —3) | Appr. below normal (—4 to —5) | Markedly below normal (—5 to —7) | More markedly below normal (—8) |
| Mar | 10.9 | 29.8 | 20.9 | 9.7 | 0.9 | 16.8 | 7.7 | 2.7 | 0.6 |
| Apr | 13.3 | 30.9 | 29.7 | 6.1 | 0.6 | 13.9 | 3.9 | 0.6 | 0.9 |
| May | 18.3 | 37.3 | 23.7 | 1.5 | — | 13.3 | 5.9 | — | — |
| Jun | 10.4 | 20.8 | 26.6 | 13.1 | 2.4 | 11.0 | 6.7 | 4.6 | 4.3 |

(*ii*) Table 2 delineates departure of different magnitudes classified as per the meteorological convention given by India Met. Dep. (1971). Values for the individual months were tabulated against the ranges in percentages. This include data of all the eleven years for the months indicated.

(*iii*) Another interesting parameter which has got high forecasting value is the persistency of a particular phenomenon for the number of days. To study the change in the trend of this parameter, it has been divided into three classifications, *viz.*, 'No change', 'Rise' or 'Fall'. 'Rise' includes the cases where the next day value is higher than previous day value by 1°C or more from the previous day value. The number of days for which one type of change has occurred is counted as unit. Analyses for the whole data looking individual days were done on this principle. All cases for the same month for different years under each category were summed up and the percentage calculated. The results are given in Table 3 which gives percentage number of continuous days on which the maximum temperature either does not change or rises or falls continuously.

### 3. Discussion of results

(*i*) Table 1 gives the percentage of changes of maximum temperature of Bhopal for different months averaged over eleven years from 1977 to 1987. It is seen from this table that cases of 'Little change' predominate in all the four months, March to June though there is a gradual increase from 39% in March to 41% in April, 46% in May and rapidly falls to a value of 38% in June. The cases of 'No change' is next to 'Little change' in the frequency spectrum. In all the months from March to April there is an increase from 21% to 34% and subsequently fall to 26% in June. It can be seen that 'Little change' and 'No change' together constitutes nearly two-third of the cases in each month. 'Rise' is next to 'No change' in March, April and June months, and in May it is the fourth in the frequency scale, third being 'Fall'. In the case of 'Rise' there is a gradual fall from March to May and then an increase in June. Frequencies of the cases of 'Appreciable rise' also follow the same trend as 'Rise'. It is inferred from the above table that there are large number of cases in the month of March where the daily increase in temperature of more than 2°C has occurred

TABLE 3

**Percentage number of cases of 'No change', 'Rise' and 'Fall' that last for one day or more**

| | No. of days | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 7 | 9 |
| | | | **No change** | | | | |
| Mar | 17.5 | 2.5 | 3.0 | 1.0 | — | — | — |
| Apr | 23.1 | 7.8 | 1.9 | 0.9 | 0.5 | — | — |
| May | 21.3 | 6.5 | 2.2 | 0.4 | 0.9 | — | — |
| Jun | 21.0 | 3.9 | 0.9 | 0.4 | — | — | 0.4 |
| | | | **Rise** | | | | |
| Mar | 22.0 | 13.0 | 1.0 | 1.0 | — | — | — |
| Apr | 22.2 | 11.6 | 1.4 | 2.8 | — | — | — |
| May | 22.6 | 9.1 | 3.0 | 0.4 | — | — | — |
| Jun | 24.1 | 8.8 | 2.6 | — | — | — | — |
| | | | **Fall** | | | | |
| Mar | 17.0 | 12.0 | 5.0 | 4.0 | 0.5 | 0.5 | — |
| Apr | 18.5 | 5.6 | 2.8 | 0.9 | — | — | — |
| May | 21.3 | 10.0 | 1.7 | 0.4 | — | — | — |
| Jun | 24.6 | 8.8 | 3.5 | 0.4 | 0.4 | — | — |

and then the number falls in April, falls further in May and then increases in June. It is interesting to note that the only case of 'Marked rise' is recorded in June. All types of positive changes; 'Rise', 'Appreciable rise' have a high frequency of occurrence in June and the only case of 'Marked rise' is also in June. The above result may be explained in a general way as due to the fact that heating at higher rates takes place for more number of days in March, comparatively less in April and least in May. The higher rate of heating in the month of June as compared to the previous months can be explained in the following way :

The geographical location of Bhopal is unique since it lies close to tropic of cancer. Sun is overhead over the station during this month and Bhopal being very close to the northernmost limit for sun's apparent northward journey, the intensity of solar heating is highest and also for larger number of days as the sun executes northwards and southwards motion over this station in close succession.

The above explanation, however, does not meet the need of a daily forecaster who has to forecast the following day's change with respect to today's synoptic situations. To meet this requirement case studies have been made. It is seen from individual day's record that whenever there are cyclonic circulation over southeast Madhya Pradesh in the lower tropospheric levels, there is a rise of maximum temperature of order of 4°C over Bhopal. With more northerly locations of the system, the increase in maximum temperature by as much as 6°C was observed in one case.

(*ii*) Table 2 brings out percentage frequency of cases of 'No change', 'Nearly normal', 'Above normal', 'Appreciably above normal', 'Markedly above normal', for the period under review. In all the months 'Nearly normal' occupies the highest percentage frequency. The group 'No change' also follows the same pattern of change, *i.e.*, increases from March to May and fall in June. The frequency of occurrence of 'No change' is third in all the four months. Case of 'Above normal' takes second place in the percentage frequency spectrum. However, this does not follow any pattern. Cases of 'Appreciably above normal' shows a fall from March to May and a rapid rise in June. Existence of cases of 'Moderate heat waves' are maximum in June with 2.4% and only 0.9% in March, 0.6% in April and *nil* in May. Cases of 'Below normal' and 'Appreciably below normal' are less as compared to the corresponding figures for their positive counter part. The number of cases where the departure in temperature are —6°C or less are more in number as compared to the positive values. Figures of 'Markedly below normal' are exceptionally high in the month of June. Case studies reveal that prior to the onset of monsoon, whenever the station is under the influence of western disturbances the fall in the temperature of the order of 6°C takes place. After the sway of the monsoon, similar departures occur when the station is under the influence of monsoon depression or other well marked systems.

(*iii*) It can be seen from Table 3 that for all the four months and for all the three types of changes there is a gradual fall with increase in the number of days. Changes that persist for one day account for nearly 60% of the cases, *i.e.*, nearly 20% under each category. Percentage of cases lasting two days account for nearly 25% of the cases. In other words, changes lasting one or two days together account for 85% of the cases. Changes that last for one day is high for 'Rise' as compared to other changes for all the months taken together. For changes that last for two days the trend is the same as that of one day persistent change but their magnitude is considerably high for 'Rise'. Changes that last for three and four days show a high 'Fall' as compared to 'Rise' and 'No change' It may be further noted that for changes of five-day duration and more, number of cases are few for 'No change and 'Fall' and *nil* for 'Rise'. Thus the result, that continuous rise of temperature do not last for more than four day, is considered useful for forecasting the changes in maximum temperature.

#### 4. Conclusion

Daily changes of maximum temperature are mostly of 'No change' or 'Little change'. Generally fall in temperature occurs when the station is affected by western

disturbances. In the month of June the station registers fall in temperature if it is under the influence of monsoon depression or other well marked weather system from the Bay of Bengal. The number of heat waves recorded over this station are *nil* in May, very few in March and April and highest in June. It is observed that whenever there is a cyclonic circulation over southeast Madhya Pradesh in the lower tropospheric levels, there is a rise in maximum temperature of the order of 4°C over Bhopal. The magnitude of the rise of the order of 6°C was observed in one case when the circulation was at more northerly location. In the case of departures 'Nearly normal' and 'Above normal' account for 50% of the cases, 'Below normal' and 'No change' 30% of the cases and the remaining cases account for 20% of the cases.

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