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The extreme values analysis of maximum and minimum temperatures over India

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ABSTRACT. Using the Fisher-Tippett Type I curve fitted by Lieblein, the extreme values of maximum and minimum temperatures obtained for 150 Indian stations for different return periods are analysed and discussed.

1. Introduction

Extreme values of any distribution of observations are of great value, particularly in problems of engineering design. Most practical applications are concerned primarily with the evaluation of return periods (or probability values). The information desired is usually either the return period of a specific value or the highest value to be expected within some specified periods. For several types of extreme value distributions, the extrapolation is sought beyond the recorded data in the direction of higher (or lower) values in order to compute the prediction of the longer estimated return period. The selection of an appropriate technique for the analysis of extreme values is of utmost importance in such studies. Jain (*see* Ref.) has arrived at such probability values for maximum wind speed over India. In the present paper the extreme value of maximum and minimum temperatures for various return periods (5, 10, 20, 50 and 100 years) have been computed and analysed.

2. Data

The annual extreme values of maximum and minimum temperatures of 150 Indian stations for 66 years over a common period (1905 to 1970) form the basic data for this study. The 66 years' data are divided into 11 sub-groups of size 6 each. For some of the stations where the data are not available over the entire period, 40 years' data over the period (1931 to 1970) have been utilized

3. Maps

Figs. 1 to 5 show the extreme value distribution of maximum temperatures for different return periods while Figs. 6 to 10 relate to the corresponding distribution of minimum temperature. Figs. 11 and 12 show the temperature distribution of highest maximum and lowest minimum temperatures available in the observatory records upto 1970.

4. Analysis and discussion

The attempt made here is to assess the probability of extremes of temperatures for different return periods using the Fisher-Tippett Type I curve fitted by Lieblein (1953). This distribution function is given by

$$F(x) = \exp\left[-\exp\left\{(x-\alpha)/\beta\right\}\right]$$

where α and β are constants. Lieblein's weighting values have been used for obtaining the constants α and β. The return period $T(x)$ is defined as the reciprocal of $1-F(x)$ where $F(x)$ is the probability level (or cumulative probability associated with a predicted value).

Lieblien has developed a linear unbiassed estimate in which the coefficients are determined

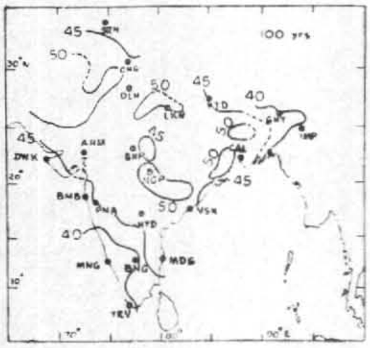

Fig. 1. 100 years

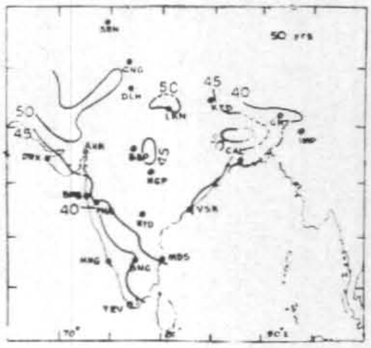

Fig. 2. 50 years

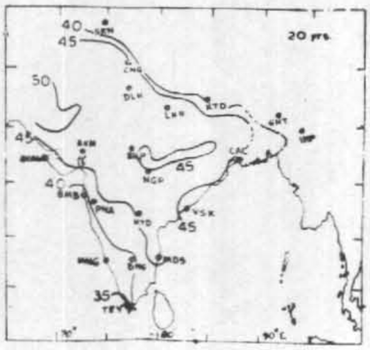

Fig. 3. 20 years

Extreme values of maximum temperature (°C) for different return periods

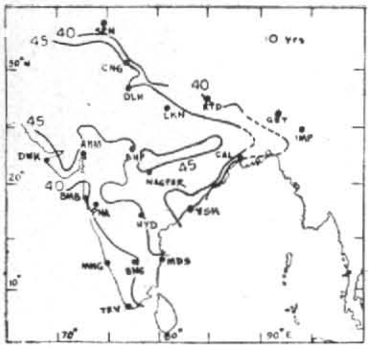

Fig. 4. 10 years

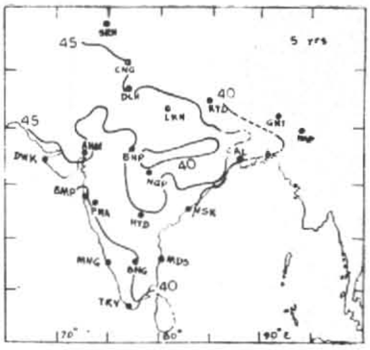

Fig. 5. 5 years

Extreme values of max. temperature (°C) for different return periods

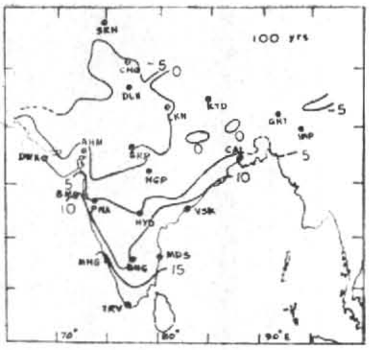

Fig. 6. 100 years

Extreme values of min. temp. (°C) for 100 yrs return period

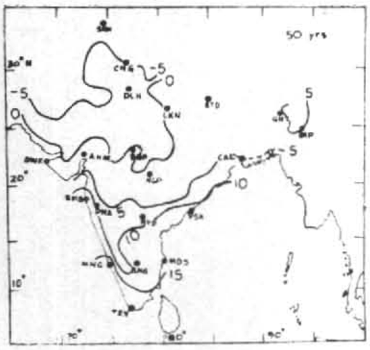

Fig. 7. 50 years

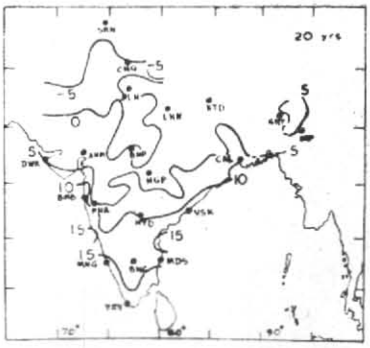

Fig. 8. 20 years

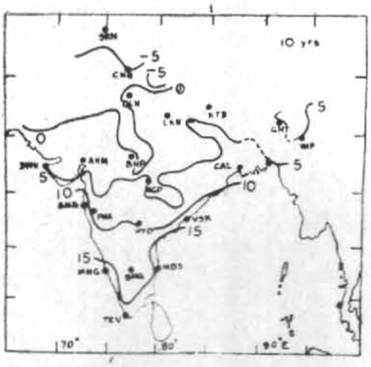

Fig. 9. 10 years

Extreme values of minimum temperature (°C) for different return periods

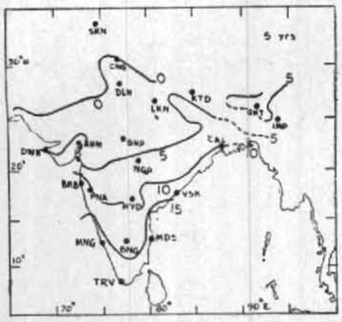

Fig. 10. 5 yrs

Extreme values of min. temp. (°C)

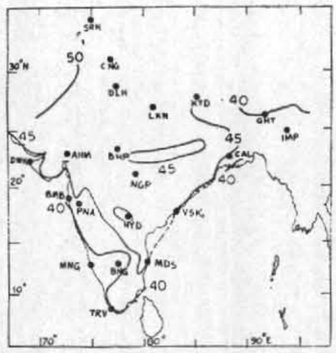

Fig. 11

Absolute max. temp.

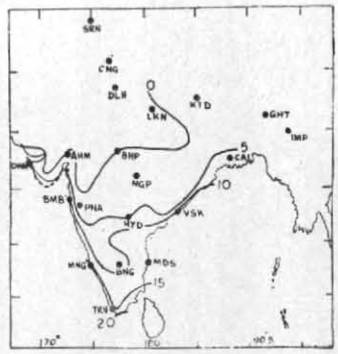

Fig. 12

Absolute min. temp.

so that the variance of the estimate is a minimum. Computation involves maintaining the original time order of the climatological series of the extremes and dividing it into suitable sub-groups. The optimum coefficients or weights have been determined explicity for samples as large as six.

The optimum weights found by Leiblein for a sample of size six are :

$W_1 = -.45028,\ W_2 = -.03599,\ W_3 = +.0719$

$W_4 = .12673,\quad W_5 = .14953,\quad W_6 = .14581$

In the present analysis, the extremes for each station are considered to be drawn at random from a common temperature population. The observations can be taken to be random as the magnitude of each observation is unpredictable from year to year and they are independent of each observation as the outcome of any station has no influence over that of any other station.

Only return periods greater than or equal to 2 are considered here, as the main interest is to obtain the extremes of maximum and minimum temperatures.

Comparison of the theoretical values with actual extremes so far recorded shows that, but for a few stations all the other stations have yet to reach the extremes for a return period of 100 years or more.

All the actual values recorded fall well within the extremes obtained by this method for different return periods. In none of the cases the actual recorded extreme value exceeded any value x within the return period $T(x)$, where $T(x)$ is the corresponding return period of that particular value x. This indicates that this method gives a slightly broader range of extremes. The difference between the actual value recorded so far and the theoretical ones, even for the highest return period 100 years, however, does not exceed 3° to 5°C.

The comparision of the maps for the different return periods shows that the pattern for the return periods of 10 and 20 years very nearly agree with the pattern of actual values. From this it may be inferred that the values even corresponding to these return periods will be a good estimate of the actual extreme, *i.e.*, in 90 to 95 per cent of the cases the value of maximum temperature will be always less than (and of the minimum temperature, more than) the values corresponding to these return periods.

In the case of maximum temperature distribution for the return periods 50 and 100 years, it is seen that there are so many regions (or pockets) which are yet to reach the temperature extreme of more than 50°C, the regions for, *e. g.*, over extreme of northwest India and West Bengal. Hence there is a possibility of the temperature reaching these extreme values within a period of 50 or 100 years though the probability of such occurrence is only 0.01 to 0.02.

Some stations have already reported extreme values which are to be expected only in 50 and/or 100 years return periods. In these cases it may very well be expected that these values will be repeated only after a lapse of 50/100 years or more.

Extreme maps for minimum temperatures indicate that the pattern for different return periods is in agreement with the pattern of actual recorded values shown in Figs. 11 and 12. Deviation of the actual, even from the highest return periods of 100 years, is below 3°C in most of the cases which may indicate that the extreme value of minimum temperature does not fluctuate very much from year to year. Northwest India, however, shows large difference between the actual and the probable values for higher return periods. This may be due to the large fluctuation of minimum temperature in this region in winter due to the passage of western disturbances.

5. Conclusion

The evaluation of the extreme values of temperature by the Fisher-Tippett Type I curve is valid and useful for shorter return periods of 5, 10 years etc. This is borne out by the fact that for most of the stations, the actual extreme values so far recorded have not yet reached the theoretical extremes for the return period of 50 or 100 years. It appears that this method gives a broader range of the extremes than will be or are actually observed.

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