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Extreme wind speeds over India

P. S. HARIHARA AYYAR and S. C. GOYAL

Meteorological Office, New Delhi

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ABSTRACT. A study of extreme wind speeds in gusts over different parts of India has been made using autographic wind data for 25 stations equipped with Dines pressure tube anemographs. Maps of India have been prepared for return periods of 2,5, 10, 25, 50 and 100 years, based on these data. These are expected to provide engineers with wind data of different probabilities which will be helpful in designing structures in different parts of the country.

1. Introduction

An attempt is made to use the available wind data in India to make a statistical assessment of the extreme wind speeds likely to occur in gusts. Maps of India have been prepared for extreme values of wind speeds in gusts that would be equalled or exceeded, on the average, once in a period of 2, 5, 10, 25, 50 and 100 years.

2. Data used

In the present study, anemograph records of 25 stations have been utilized. Maximum speeds of gusts were noted from the anemograph records for individual sites and annual peaks were selected. For stations equipped with more than one anemograph located at different sites, the highest recorded peak in a year at any of the sites has been considered as the representative annual peak for the station.

3. Variation of gusts with height

The heights of wind instruments at the different stations vary, but most of them are in the range of 10 to 30 m. The question of reduction of extreme gust values to a height of 10 m was examined in the light of available information.

In India it has been found that two anemographs located in the same station at nearby sites with different heights above ground have not shown any relationship for extreme winds. Further, the anemograph at a lower elevation has sometimes recorded a higher gust speed than the one at the higher elevation at the same station. For the above reasons, reduction of the gust data to the standard height of 10 m has not been made.

Fisher and Tippett (1928) suggested three possible distributions of extremes, Type I, Type II and Type III. Gumbel (1941) applied widely the Type I distribution to rainfall extremes and it is often referred to also as Gumbel's distribution. Shellard (1958) applied Gumbel's extreme value method for the study of the extreme wind speeds over Great Britain and Ireland. Application of Type I distribution or Gumbel's method (1941) to the annual series data is widely used and has been found to lead to fairly consistent estimates.

Accordingly, annual gust peak series of all 25 stations under study were analysed using Gumbel's extreme value method. The parameters were estimated by minimising the "Error Sum of Squares", as Chow (1953) has categorically stressed its greater precision over the method of moments. Table 1 shows the list of stations under study and the mathematical relationship between the magnitude of the annual gust peak and its return period in the form of a straight line.

It is sometimes observed that the Type I distribution underestimates the values for lower return periods. Therefore, the use of Type II distribution has been suggested by some workers. This distribution has a lower limit for the less extreme values, but the more extreme values are highly exaggerated. Since meteorological parameters like wind and rain cannot have an unlimited upper value, Type II distribution is not quite applicable for higher return period values (WMO 1969). It is, therefore, considered better to use the Type I distribution to evaluate results.

No details are being given here regarding the Type I distribution on account of its being well-known.

4. Extreme wind speed maps for different return periods

The computed values of wind speeds that are likely to be equalled or exceeded once during given periods are presented in the return period

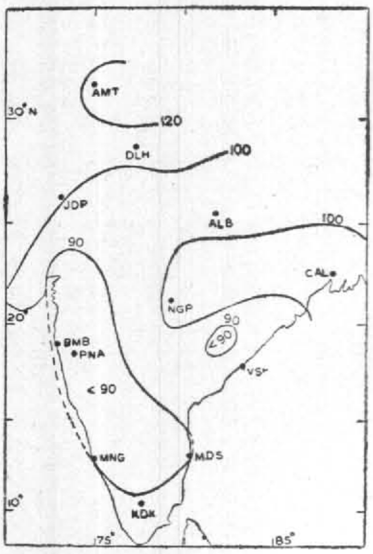

Fig. 1. 2-yr. period

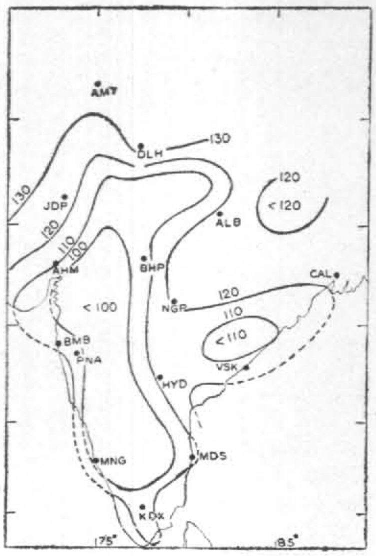

Fig. 2. 4-yr. period

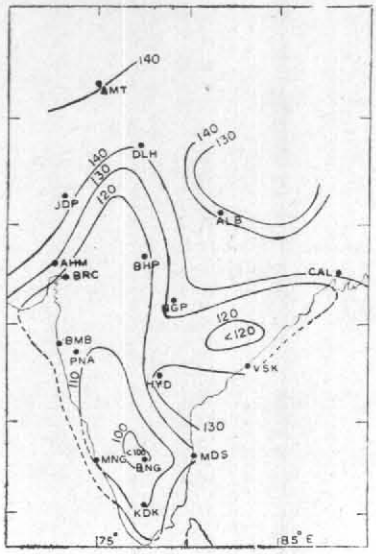

Fig. 3. 10-yr. period

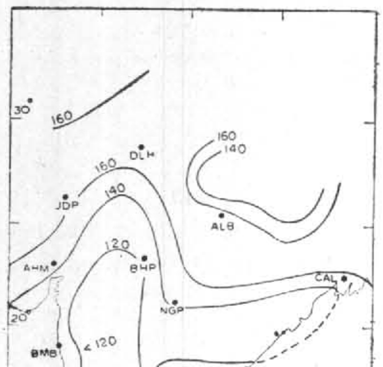

Fig. 4. 25-yr. period

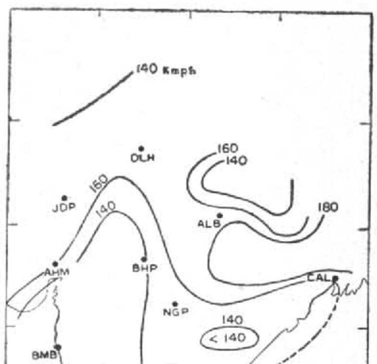

Fig. 5. 50-yr. period

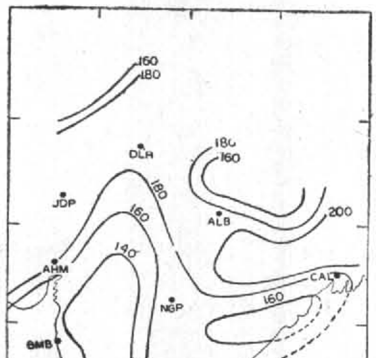

Fig. 6. 100-yr. period

Wind speed (kmph) in different return periods

TABLE 1

Theoretical relationship between extreme wind speed and its return period (based on Fisher Tippett Type I distribution)

Station	Period of data used (years)	Line of best fit $X_{(T)} = a+bY_{(T)}$	
		a	b
Port Blair	8	96·0485	12·2737
Bombay	21	84·0519	12·9573
Calcutta	20	108·2731	14·6870
Jaipur	10	76·8762	21·0411
Allahabad	18	87·5038	23·2968
Amritsar	6	123·8349	5·9933
New Delhi	15	105·4943	17·2234
Ahmadabad	13	81·6599	21·4949
Veraval	7	88·7601	13·9712
Baroda	9	65·2838	7·4500
Poona	19	81·2947	14·8505
Nagpur	17	97·6344	15·3667
Visakhapatnam	19	88·9442	17·1334
Hyderabad	16	88·7615	19·3614
Saugar Island	14	97·6325	12·9005
Gaya	19	93·3516	15·3461
Gopalpur	15	93·3516	15·3381
Jamshedpur	20	100·6598	21·6984
Lucknow	9	87·7768	12·8606
Bhopal	14	91·7816	10·7882
Jagdalpur	8	78·2441	14·4481
Kodaikanal	21	88·6619	8·3505
Bangalore	18	79·4330	8·7374
Madras	15	83·6597	15·9654
Jodhpur	13	94·6324	20·7892

$X_{(T)}$ = Extreme wind speed in km/hr likely to be reached or exceeded once in T years.

$Y_{(T)}$ = Reduced variate;

a and b are constants.

maps for 2, 5, 10, 25, 50, and 100 years in Figs. 1 to 6. The return period values used for the preparation of these maps are based on Fisher Tippett Type I distribution. The maps are based on very limited data and this should be borne in mind in making use of them. In the Gumbel's extreme value method a 2·33-year return period estimate corresponds to the mean value of the frequency distribution. The 2-year return period (map at Fig. 1) can thus be utilised for estimating wind speeds which are likely to occur most frequently in the annual gust peaks. Return period maps of 50 and 100 years are of more practical utility to the design engineers for construction of structures which should stand for at least about a century.

It may be seen from the return period maps that the regions of strongest gust speeds are in north India, while over the east coast of India the gusts are relatively weaker. This shows that the short period squally winds associated with thunderstorms and duststorms of north India are stronger than even the gales associated with cyclonic storms which affect the coastal regions of the country, particularly the east coast. It should however, be remembered that the gales associated with cyclonic storms are of much longer duration and hence their potential for damage has to be assessed on the basis of not only the speed but also the duration.

5. Conclusion

In assessing the extreme wind speeds over India one has to keep in mind that although the coastal areas of the country, particularly the east coast, do record severe gales and these are of several hours' duration areas in north India experience even stronger winds associated with thunderstorms and duststorms although these are short-lived and sometimes highly localised. In designing structures, one has to bear in mind this difference and make necessary provision.

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