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An investigation of monthly mean maximum and absolute maximum temperatures of Bangladesh

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सार — बंगलादेश के 16 केन्द्रों के 27 वर्षों (1951–1977) के सिनॉप्टिक और जलवायुवी आंकड़ों का प्रयोग करते हुए वहां के चरम अधिकतम तापमान के कालिक तथा स्थानिक चलनों का अध्ययन किया गया है। चरम अधिकतम तापमान के 35.1°–40.0° सें० और 40.1°–45.0° सें० अन्तराल की आनुभाविक संभावनाओं का परीक्षण किया गया है। चुने हुए महीनों के लिए कुछ केन्द्रों के युगलों के मध्य कुछ सहसंबंधी अभिलक्षणों का विश्लेषण किया गया है। सिनॉप्टिक मौसम विज्ञान की दृष्टि से अधिकतम और चरम अधिकतम तापमानों के कालिक तथा स्थानिक चलनों के कारण को स्पष्ट करने का प्रयास किया गया है।

ABSTRACT. Using synoptic and climatological data for 27 years (1951-1977) of 16 stations of Bangladesh, temporal and spatial variations of the absolute maximum temperature of Bangladesh have been studied. Empirical probabilities for the interval 35.1°-40.0°C and 40.1°-45.0°C of absolute maximum temperature have been examined. Some correlation characteristics between some pairs of stations for some selected months have been analysed. An attempt has been made to explain the cause of temporal and spatial variations of maximum and absolute maximum temperatures from the point of view of synoptic meteorology.

Key words — Absolute maximum temperature, Correlation coefficient, S. D., Empirical probability.

1. Introduction

Investigation of maximum temperatures may be interesting for Bangladesh, mainly from the agricultural point of view. It has been found that plants grow, develop and give yield in a certain range of temperature (Sinissina *et al.* 1973). Maximum temperatures define the climatological potentiality of the agricultural planning for particular crops to a certain extent. As a matter of fact, maximum temperature may give information about the upper limit of temperature for plant growing and hence, for optimum yielding for particular crops. It has been seen that high temperatures are related to drought (Sinissina *et al.* 1973), which is one of the fundamental weather hazards in agriculture. Maximum and absolute maximum temperatures are two important parameters taken into account in construction engineering (Zavarina 1976).

In connection with the above views, an investigation of the maximum and absolute maximum temperatures in Bangladesh have been studied. In the present paper, emphasis is put on the study of the annual variation and spatial distribution of the above elements to have a climatic picture of Bangladesh. Temperature exceeding 35° C is regarded harmful in agriculture and construction engineering (Guraev *et al.* 1977). Considering this point of view, some empirical probability characteristics have been analysed for limits of temperature above 35° C and 40° C.

In climatological findings very often the 'representativeness' of certain meteorological stations are tested for defined elements. In view of this, stability between pairs of stations are examined. Keeping this in mind, a study of the variation of correlation coefficients for a few pairs of stations of Bangladesh for selected months (March, April and May) have accomplished. In course of the investigation, an attempt has been made to look for the synoptic cause of temporal and spatial variations of the maximum and absolute maximum temperatures in Bangladesh.

Results obtained in the present investigation may be effectively used in the formulation of long range weather forecasting as well as in different fields of the national economic planning of Bangladesh.

2. Materials and method

In the present investigation, monthly values of mean maximum and absolute maximum temperatures of 16 stations for a period of 27 years (1951 – 1977) obtained from Bangladesh Meteorological Department have been used. The locations of the stations are shown in the Fig. 2*.

In methodology, the following procedure have been adopted :

2.1. *Mean monthly maximum tempearture* — It has been defined as the average maximum temperature of

*The political boundaries in the base maps used may not be to the scale.

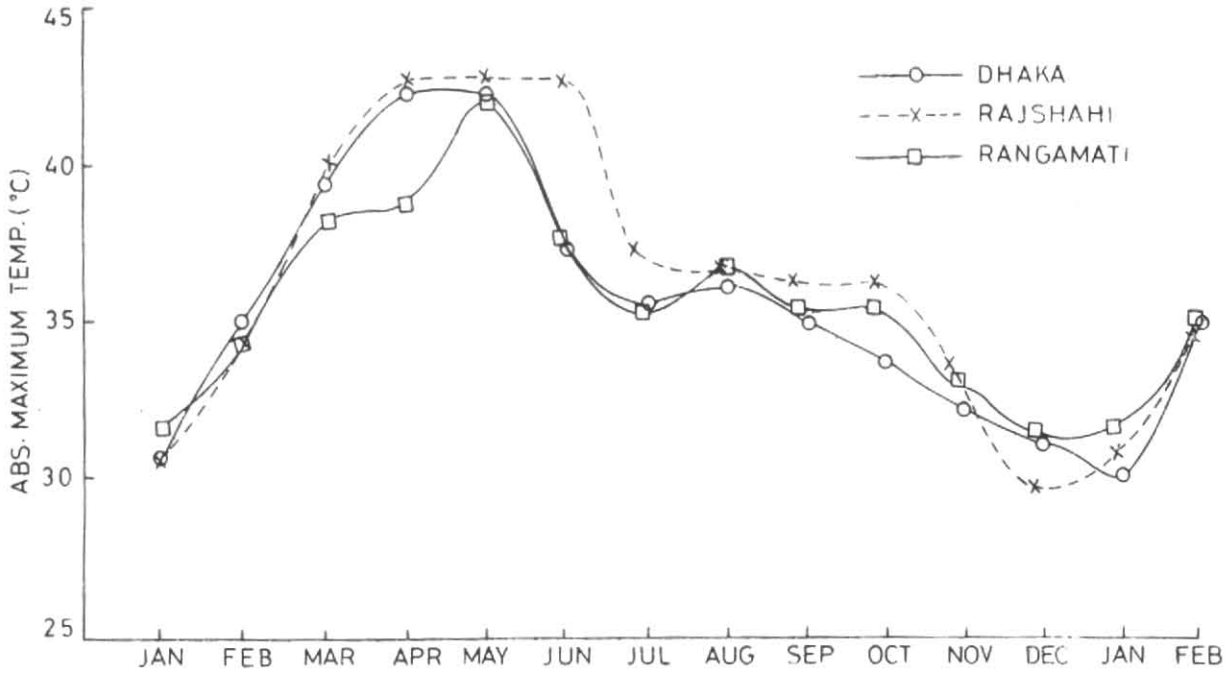

Fig. 1. Annual variation of monthly mean maximum temperature (°C) for some selected stations of Bangladesh

TABLE 1

Absolute maximum temperature (°C) in Bangladesh for different months

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Amplitude
Dhaka	30.5	35.0	39.4	42.2	42.2	37.2	35.5	36.1	35.1	33.8	32.2	31.1	11.7
Faridpur	32.7	35.0	40.5	41.6	41.6	36.6	35.5	35.0	35.0	36.6	33.8	30.5	11.1
Bogra	31.1	35.0	40.0	42.7	43.3	38.8	36.6	37.2	36.1	35.0	32.7	30.5	12.8
Sylhet	29.4	32.2	36.6	38.8	40.5	35.5	36.6	37.7	37.2	35.0	32.2	31.1	11.1
Maijdee Court	32.7	34.4	37.7	42.2	42.2	35.5	36.6	36.1	35.5	35.0	33.3	31.0	11.1
Mymensingh	30.0	33.3	37.2	40.5	40.0	37.2	36.6	37.7	35.5	36.6	33.3	30.0	10.5
Comilla	32.2	35.0	37.7	40.5	41.6	37.2	36.6	37.7	35.5	36.6	33.3	32.7	9.4
Rajshahi	30.5	34.4	40.0	42.7	42.7	42.7	37.2	36.6	36.1	36.1	33.3	29.5	13.2
Jessore	32.2	36.6	41.1	42.7	42.2	40.5	35.5	35.5	36.6	37.2	32.7	31.6	11.1
Barisal	31.6	35.0	36.6	41.1	38.3	36.1	35.0	36.1	35.0	35.0	32.7	31.6	9.5
Chittagong	31.6	33.8	36.1	39.4	40.5	35.0	35.0	33.8	34.4	35.0	32.7	31.6	8.9
Khulna	32.2	36.1	39.4	40.5	42.7	39.4	37.2	36.1	37.2	36.1	33.8	35.5	10.5
Rangpur	28.8	35.0	38.8	40.5	42.7	40.5	41.1	37.2	37.2	35.0	33.8	32.2	13.9
Cox's Bazar	31.1	33.8	37.2	37.2	36.1	40.5	33.8	33.8	35.5	36.1	33.8	32.2	9.4
Ishurdi	31.1	34.4	39.4	42.2	43.8	43.3	39.4	34.4	36.1	35.0	33.8	35.0	12.7
Rangamati	31.6	35.0	38.3	38.8	42.2	37.7	35.5	36.6	35.5	35.5	33.3	37.6	10.6

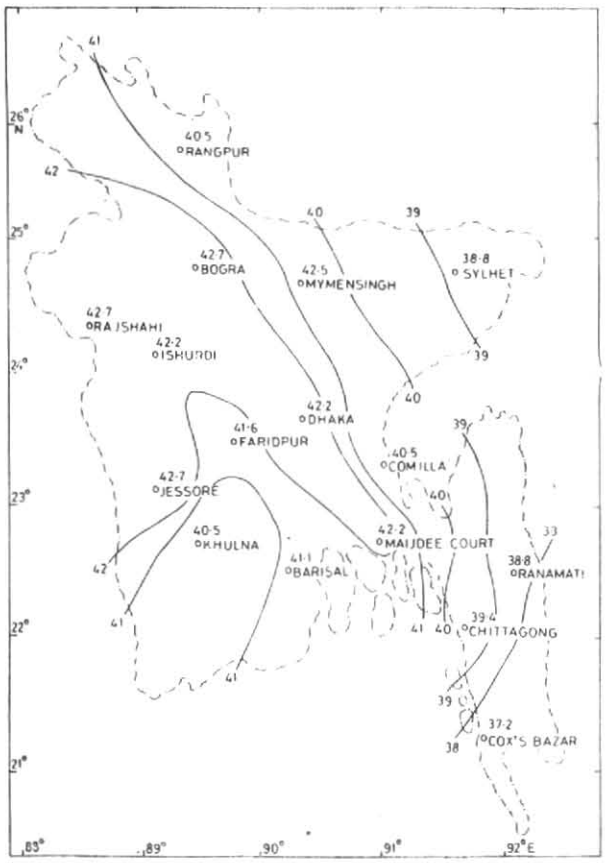

Fig. 2. Location of the meteorological stations and spatial distribution of absolute maximum temparature (°C) of Bangladesh, the data of which have been used in the paper

air observed at a particular place for a particular month as in the present investigation (Chromov *et al.* 1974, Kobisheba *et al.* 1978).

2.2. Absolute maximum temperature is defined as the highest value of temperature observed in a particular month at a particular place in the whole series of observation (Chromov and Mamontova 1974, Kobisheba and Narovlianskii 1978).

2.3. Mean values, standard deviation and correlation coefficient have been defined by using standard statistical formulae (Gulinova 1974, Kelcheavskiia 1971, Kobisheba and Narovlianskii 1978).

2.4. Empirical probability has been defined by (Gulinova 1974, Kelcheavskiia 1971, Sinissina *et al.* 1973).

$$P = \frac{m}{n+1} \times 100$$

where, m is the number of events that occurred in a particular interval and n is the total number of cases.

2.5. Annual variation curves have been prepared for absolute maximum and mean maximum temperatures.

2.6. Carthographic analysis has been done to establish the spatial variation patterns.

3. Results and discussion

3.1. *Monthly absolute maximum temperature*

The values of the monthly absolute maximum temperature may be obtained in Table 1.

(*i*) *Annual variation* — From the analysis of the annual variation curves (Fig. 1), it comes out that the lowest of absolute maximum temperature is found mainly in January. Absolute maximum tempertaure begins to rise sharply from February and the rate of rise is maximum in April. In most of the cases the highest of the absolute maximum temperature takes place in April or May. With the onset of southwest monsoon in Bangladesh in June, absolute maximum temperature decreases to a certain extent. In some cases, a secondary maximum occurs in August, when 'monsoon break' takes place.

(*ii*) *Spatial distribution* — Analysis of the monthly absolute maximum temperature in Bangladesh shows that in December – February the zone with the highest temperature is observed in the southwestern coastal districts of the country. The values decrease gradually towards the northeast. From March a reorientation in the temperature field is marked. The zone with the highest values shifts towards the central western portion of Bangladesh. Here the isotherms are quasi-meridional decreasing the values towards the east. In April, May and June almost the similar patterns are maintained (Fig. 2). In July, the zone with the highest value of the absolute maximum temperature shifts towards the extreme northwestern part of Bangladesh and a sharp decrease is marked towards the southeast. It is noted that the zone highest absolute maximum temperature is located in the northeastern part of Bangladesh in August and September. From October the zone with the highest value of absolute maximum temperature shifts towards the southwestern part of the country. From the analysis of the spatial distribution of absolute maximum temperature, it comes out that a sharp contrast between the east and the west of Bangladesh is marked in the months, March – July.

(*iii*) *Probability distribution* — Empirical probability of the absolute maximum temperature for the intervals 35.1° – 40.0° C and 40.1° – 45.0° C have been shown in Tables 2 (a & b).

(*iv*) *Annual amplitude* — In the spatial distribution of annual amplitudes (Table 1), the variation is observed from the northwest to the southest (from 13.9° C to 8.9° C). The isotherms are quasi-meridional.

(*v*) *Some correlation characteristics* — In the present study some correlation characteristics of absolute maximum temperature for the stations Chittagong, Comilla, Dhaka, Faridpur, Bogra and Rangpur for the months March-May have been investigated. Correlations have been searched for the pairs Dhaka-Chittagong, Dhaka-Comilla, Dhaka-Faridpur, Dhaka-Bogra and Dhaka-Rangpur. In every case, the relation is linear. The correlation coefficients may be obtained in Table 3. It is seen from the table that correlation coefficients vary from 0.25 to 0.82 for different pairs for different months. These correlation coefficients may give us a picture of the stability of the stations with respect to absolute highest temperature and thus, gives outlines about the representativeness of

TABLE 2(a)

Empirical probabilities (%) of the absolute maximum temperature for the interval 35.1°-40.0° C for some stations of Bangladesh for some selected months

Station	Probability (%) for months							
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dhaka	4.0	95.7	73.9	73.9	50.0	9.1	4.3	13.0
Faridpur	7.4	96.2	70.4	76.9	64.0	11.5	8.0	8.0
Bogra	4.2	91.7	50.0	59.1	68.2	22.7	22.7	36.4
Sylhet	0.0	47.4	52.6	47.1	50.0	49.1	26.3	52.6
Maijdee Court	0.0	57.7	60.0	52.0	25.0	4.3	4.3	8.7
Mymensingh	0.0	66.7	87.5	75.0	64.3	33.3	29.4	50.0
Comilla	4.3	86.7	85.7	70.0	52.4	14.3	19.4	38.1
Rajshahi	11.8	86.7	7.1	35.7	53.8	25.0	37.5	43.8
Jessore	32.0	91.7	16.7	52.2	73.9	25.0	20.8	41.7
Barisal	4.3	82.6	87.0	83.3	45.8	16.7	12.5	12.5
Chittagong	0.0	32.0	52.2	38.5	15.4	8.0	0.0	0.0
Khulna	20.0	91.7	87.5	84.6	87.5	40.0	20.8	62.5
Rangpur	5.3	89.5	82.4	58.8	83.3	57.9	52.6	57.9
Cox's Bazar	0.0	16.0	30.4	16.7	4.2	0.0	0.0	4.2
Ishurdi	0.0	95.7	42.9	4.0	73.3	40.0	0.0	6.7
Rangamati	7.1	85.7	84.6	85.7	69.2	14.0	50.0	64.3

TABLE 2(b)

Empirical probabilities (%) of the absolute maximum temperature for the interval 40.1°-45.0°C for some stations of Bangladesh for some selected months

Station	Probability (%) for months			
	Mar	Apr	May	Jun
Dhaka	0.0	4.2	8.7	0.0
Faridpur	3.7	22.2	7.7	0.0
Bogra	4.2	45.5	36.4	0.0
Sylhet	0.0	0.0	5.9	0.0
Maijdee Court	0.0	4.0	4.0	0.0
Mymensingh	0.0	6.7	0.0	0.0
Comilla	0.0	4.8	6.7	0.0
Rajshahi	0.0	85.7	50.0	38.5
Jessore	4.2	70.8	77.0	8.7
Barisal	0.0	4.2	0.0	0.0
Chittagong	0.0	0.0	3.8	0.0
Khulna	0.0	8.4	11.5	0.0
Rangpur	0.0	11.8	23.5	5.3
Cox's Bazar	0.0	0.0	0.0	4.2
Ishurdi	0.0	50.0	53.3	13.0
Rangamati	0.0	0.0	7.1	0.0

TABLE 3

For different selected months correlation coefficients of absolute maximum temperature and value of 'm' and 'c' (regression equations) for different pairs of stations of Bangladesh

Pairs of stations	Months	m	c	Correlation coefficient
Dhaka-Chittagong	Mar	0.42	18.6	0.42
	Apr	0.62	11.0	0.62
	May	0.43	15.7	0.60
Dhaka-Comilla	Mar	0.23	27.6	0.25
	Apr	0.65	12.0	0.75
	May	0.62	13.1	0.82
Dhaka-Faridpur	Mar	0.83	6.4	0.64
	Apr	0.63	14.7	0.72
	May	0.67	12.6	0.77
Dhaka-Bogra	Mar	0.91	4.5	0.63
	Apr	0.63	16.2	0.64
	May	0.85	7.4	0.73
Dhaka-Rangpur	Mar	0.79	7.0	0.67
	Apr	0.39	23.3	0.55
	May	0.49	20.1	0.56

TABLE 4

Monthly mean maximum temperature (°C) for different months for some stations of Bangladesh

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Amplitude
Dhaka	27.9	32.9	36.7	38.3	36.8	34.4	33.2	33.0	33.8	33.0	30.7	28.3	10.4
Faridpur	27.3	32.2	37.0	38.9	37.2	35.0	33.4	33.0	33.9	32.2	30.6	27.5	11.6
Bogra	27.6	32.3	37.8	40.4	38.8	35.5	34.2	33.9	34.6	33.5	31.2	28.5	12.8
Sylhet	27.4	30.4	34.6	35.3	35.1	34.4	34.7	34.2	34.8	33.5	30.9	28.4	7.9
Maijdee Court	28.4	31.3	34.8	35.2	35.3	33.6	32.9	32.6	33.5	33.1	30.3	28.4	6.9
Mymensingh	27.3	31.2	35.5	37.8	36.0	35.1	33.9	34.2	34.3	35.0	33.0	30.0	10.5
Comilla	28.8	32.3	36.0	36.9	35.9	35.0	33.8	34.0	34.2	33.8	31.7	29.9	8.1
Rajshahi	27.7	32.8	36.8	40.9	40.4	33.7	34.3	34.5	34.5	33.8	31.5	28.3	13.2
Jessore	29.0	33.6	37.7	40.5	39.5	36.8	34.0	33.9	34.5	32.2	30.6	27.5	13.0
Barisal	28.4	32.3	35.4	37.0	35.9	34.5	33.3	33.4	33.9	33.5	30.9	28.8	8.6
Chittagong	28.6	31.2	34.0	34.7	34.6	33.5	33.0	32.7	33.2	33.1	33.2	29.0	6.1
Khulna	29.5	33.6	37.1	38.4	38.1	35.1	34.4	34.1	34.9	34.5	31.9	30.2	8.9
Rangpur	26.6	30.4	36.1	38.4	38.2	36.6	35.1	35.0	35.0	33.5	31.4	27.9	11.8
Cox's Bazar	29.1	31.1	33.6	34.1	34.1	33.3	32.2	32.1	32.9	33.4	31.7	29.5	5.0
Ishurdi	28.2	32.4	37.7	40.4	40.2	37.4	34.5	33.6	34.4	33.5	31.4	28.8	12.2
Rangamati	29.8	32.9	35.6	37.2	37.9	35.5	34.6	34.7	34.8	34.4	32.0	29.8	8.1

the meteoroglogical stations in Bangladesh. On the basis of correlation coefficients a set of regression equations have been obtained. The model equation is $y_i = mx + c$ where, y_i stands for Chittagong, Comilla, Faridpur or Rangpur, as the case may be; and x stands for Dhaka. The values of m and c may be obtained in Table 3.

3.2. *Mean monthly maximum temperature*

(*i*) *Annual variation* — The values of mean monthly maximum temperature in Bangladesh may be obtained in Table 4. Analysis reveals that minimum of it occurs in January while the maximum occurs mainly in April.

(*ii*) *Spatial distribution* — In December-February the highest value of the mean monthly maximum temperature is situated in the southwestern part of Bangladesh. In March-June the zone with the highest value is located in the central western portion of the country decreasing towards the east. In July-September the temperature field becomes almost uniform. In October – November a reorientation in the temperature field is marked with two separate zones of the higher values in the southeastern and southwestern portion of the country respectively.

(*iii*) *Annual amplitude* — In the spatial distribution of annual amplitudes (Table 4), it is seen that there are two distinct zones : (a) in the western portion of Bangladesh with highest values decreasing towards the east, and (b) with the lowest values in southeastern coastal areas increasing towards the northeast of the country. The annual amplitudes lie within 5.0°-13.2° C.

3.3. *Synoptic cause of variation*

Synoptic processes like the periphery of Asiatic anticyclone, western disturbances, etc are dominant during November-February in Bangladesh and its surrounding areas. These weather processes carry cold air mass from the north as well as from the west. As a result, the minima in the variation of the absolute maximum and mean maximum tempeartures are observed in these months. In Bangladesh and its surrounding areas temperature starts rising rapidly from the middle of February, when heat lows originate, develop and intensify. These heat lows are frequent and most intensive in Bangladesh and its surrounding areas in April and May, which ultimately cause the occurrence of maximum in the annual variation of the absolute maximum and mean maximum temperatures in the country.

In the spatial variation of the mentioned elements in November-February, the warm influence of the Bay of Bengal is well reflected. So, the temperature falls down from the coastal regions towards the interior of the country. With the development and progressive intensification of heat low from March over north India, its trough extends into Bangladesh and becomes well marked in April, May and June. With the onset of the southwest monsoon over Bangladesh in late May and early June and its activity during July-September, almost uniform maximum temperatures are observed in the country. With the withdrawal of monsoon over the country by the middle of October a reorientation in the temperature field takes place.

Local factors also influence the temperatures in addition to the factors mentioned above.

4. Conclusions

(*i*) The lowest values of absolute maximum temperature and mean monthly maximum temperature occur in January and the highest values in April or May. The minimum is observed, when 'the periphery of Asiatic anticyclone' is dominant in Bangladesh. The maximum occurs, when heat lows are most intensive and frequent.

(*ii*) In November-February the zone with highest absolute maximum temperature as well as the mean monthly maximum temperature is observed in the south western coastal areas of Bangladesh, which may be due to the warm effect of the Bay of Bengal. During March to June the zone the highest temperature is found in the western part of Bangladesh. During July to September the distribution of absolute maximum and mean monthly maximum temperatures are more or less flat over Bangladesh, due to the monsoon in Bangladesh.

(*iii*) Annual amplitudes of the absolute maximum temperature and mean monthly maximum temperature are higher in the western part of the country than in the east.

(*iv*) Correlation characteristics have been obtained for the pairs of stations Dhaka-Comilla, Dhaka-Faridpur, Dhaka-Bogra and Dhaka-Rangpur for the months March, April and May and a set of regression equations for absolute maximum temperature thus have been computed.

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