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Further studies on runway temperature and screen temperature observations made at Dum Dum Airport, Calcutta

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ABSTRACT. Result of a study of runway and screen temperature observations made at Dum Dum airport, Calcutta at six synoptic hours (00, 03, 06, 09, 12 and 18 GMT) for a period of 21 months was reported earlier by the author. The same has now been extended for a further period of 24 months. The result of the study for the entire period of 45 months, reveals that the runway temperature is generally higher than the screen temperature, the average value of difference of runway and screen temperature readings being generally less than 1°C. In extreme cases, the absolute value of the difference could be as high as ±4°C. The diurnal and seasonal variation of the difference has been discussed. The effect of surface wind, radiation and other factors on the value of the differene has been also discussed.

1. Introduction

In an earlier communication (De 1963), the result of a preliminary study on the runway and screen temperature observations made at Dum Dum Airport, Calcutta has been reported. The conclusions arrived at from the above study have, however, been tentative due to the paucity of the number of observations. The study was continued for a further period of two years and the result is presented in this communication.

2. Data Used

Temperature observations were simultaneously recorded in the Stevenson Screen enclosure at the Dum Dum Observatory in the usual way and over the runway at Dum Dum Aerodrome by a sling psychrometer at six fixed synoptic hours (00, 03, 06, 09, 12 and 18 GMT). The earlier preliminary study was in respect of data recorded for a period of 21 months from 1 February 1959 to 31 October 1960 which was continued for a further period of 24 months from 1 November 1960 to 31 October 1962. The data for the entire period of 45 months have been combined and the result presented in this communication. The temperature observations were recorded on 4835 occasions as shown in Table 1.

The number of observations and the average values of Runway *minus* Screen temperature (R—S) readings are presented in Table 2. For the sake of convenience, the average difference between the Runway and Screen temperature values (R—S) in different months have been graphically represented in Fig. 1.

3. Analysis of the Data

3.1. *Range of difference* — It is seen from Table 2 and also from Fig. 1 that the average difference of runway and screen temperature readings during the entire period is generally positive (except at 1200 GMT during February). This means that on the average, the runway temperature is higher than the screen temperature. The maximum difference is 1·5°C at 0300 GMT during November. The range of the difference varies from —0·1°C to +1·5°C. The difference is more than 1°C at 0300 GMT during November, December and January and at 0600 GMT during January. The screen temperature is higher than the runway temperature only at 1200 GMT during February.

3.2. *Maximum and minimum range of difference* — It has been found that though the average value of the difference is generally positive, there are individual occasions when the screen temperature is higher than the runway temperature. The extreme range of the difference is between —3·0°C (at 0600 GMT in March 1967) and +4·2°C (at 0600 GMT in October 1961). The number of such extreme cases is, however, small. This results in the average value of the difference of runway and screen temperature to be of the order of 0·7°C.

3.3. *Diurnal variation* — The average value of the difference is found to be oscillating between the maximum and minimum limits. The value of the difference is maximum at 0300 GMT except during the monsoon months (July—September) and minimum generally at 1200 GMT.

TABLE 1

Number of observations during different months (from February 1959 to October 1962) at different synoptic hours

	Synoptic hours (GMT)						Total
	00	03	06	09	12	18	
Jan	61	65	59	65	64	52	366
Feb	71	50	44	76	79	69	389
Mar	67	69	58	75	79	74	422
Apr	67	64	51	70	75	80	407
May	69	73	53	56	62	66	379
Jun	59	70	58	61	66	58	372
Jul	66	59	58	62	61	53	359
Aug	72	74	70	78	78	67	439
Sep	90	77	68	77	81	81	474
Oct	82	81	58	74	77	74	446
Nov	69	69	59	59	69	64	389
Dec	60	66	62	66	74	65	393
Total	833	817	698	819	865	803	4835

TABLE 2

Average values of Runway (R) and Screen (S) temperature observations recorded at Dum Dum Airport during the period February 1959 to October 1962

	00 GMT		03 GMT		06 GMT		09 GMT		12 GMT		18 GMT	
	N	AV	N	AV	N	AV	N	AV	N	AV	N	AV
Jan	61	+0·5	65	+1·2	59	+1·2	65	+0·4	64	+0·5	52	+0·5
Feb	71	+0·3	50	+1·0	44	+0·5	76	+0·6	79	—0·1	69	+0·2
Mar	67	+0·5	69	+0·8	58	+0·9	75	+0·7	79	+0·2	74	+0·5
Apr	67	+0·7	64	+1·0	51	+0·9	70	+0·7	75	+0·3	80	+0·4
May	69	+0·7	73	+0·9	53	+0·6	56	+0·8	62	+0·2	66	+0·4
Jun	59	+0·6	70	+0·7	58	+0·6	61	+0·6	66	+0·3	58	+0·3
Jul	66	+0·4	59	+0·4	58	+0·7	62	+0·5	61	+0·3	53	+0·3
Aug	72	+0·6	74	+0·5	70	+0·7	78	+0·5	78	+0·3	67	+0·4
Sep	90	+0·3	77	+0·4	68	+0·5	77	+0·3	81	+0·3	81	+0·3
Oct	82	+0·5	81	+0·8	58	+0·6	74	+0·3	77	+0·3	74	+0·3
Nov	69	+0·7	69	+1·5	59	+0·7	59	+0·4	69	+0·5	64	+0·8
Dec	60	+0·7	66	+1·3	62	+0·5	66	+0·5	74	+0·4	65	+0·8

N=Number of observations AV=Average values of R—S

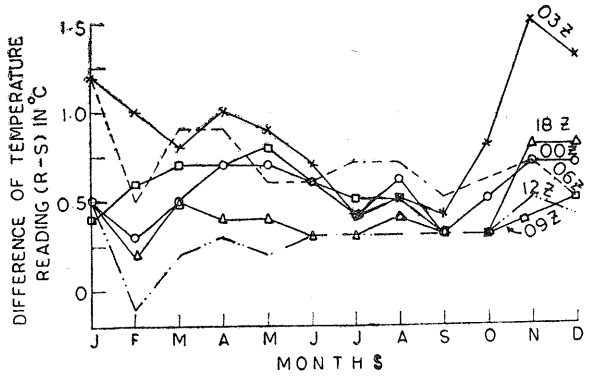

Fig.[1]

Curves showing the variation of difference of Runway te mperature (R) and Screen temperature (S) against months of the year as recorded at Dum Dum Airport during the period February 1959 to October 1962

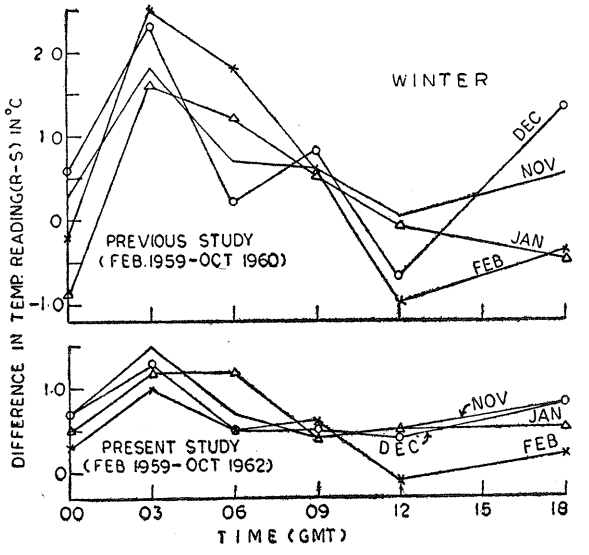

Fig. 2(a)

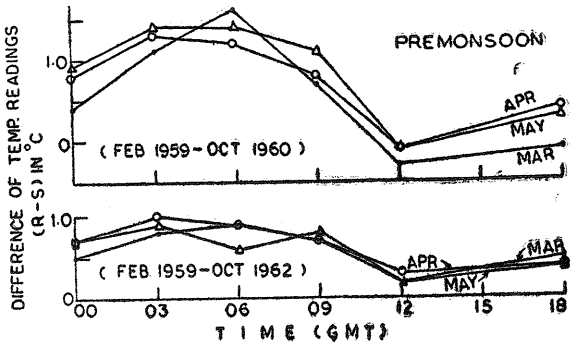

Fig. 2(b)

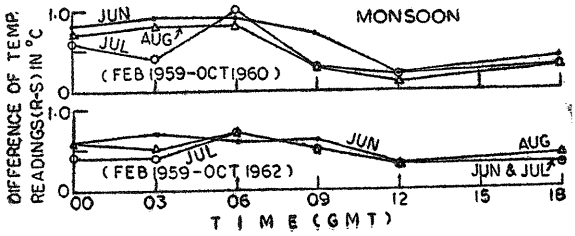

Fig. 2(c)

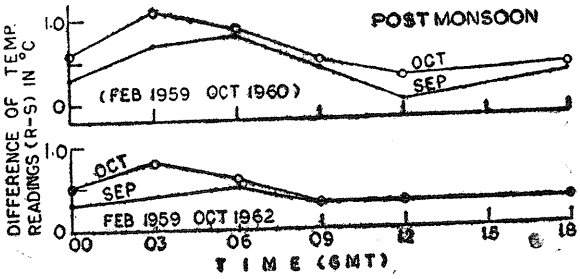

Fig. 2(d)

Figs. 2(a-d). Curves showing the variation of difference of Runway temperature (R) and Screen temperature (S) against time during different seasons as recorded at Dum Dum Airport during the period February 1959 to October 1962

3.3.1. Salient features of variations of the difference of runway and screen temperature observations taken at different synoptic hours are shown in Table 3. It may be seen that the mean value of all average differences recorded in various months lies between +0·3 and +0·9°C, the maximum (*i.e.*, +0·9°C) being at 0300 GMT and the minimum (*i.e.*, +0·3°C) at 1200 GMT. The extreme values of average differences may be as high as +1·5°C (at 0300 GMT in November) and as low as —0·1°C (at 1200 GMT in February). It may also be seen that the runway temperature may be higher than the screen temperature by as much as 4°C and lower by about 2 to 3°C.

3.4. *Seasonwise variation* — Next, the available data have been analysed seasonwise. For this purpose, the data have been classified into four predominant seasons, *viz.*, Winter (November-February), Premonsoon (March-May), Monsoon (June-August) and Post-monsoon (September-October). The data are represented graphically in Fig. 2. For the sake of comparison the data of the previous study (De 1963) are also shown in the same figures.

3.4.1. *Winter* — It is seen from Fig. 2(a) that during the winter season, the average difference of the runway and screen temperature readings increases with the advance of the day upto 0300 GMT. The difference then tends to decrease and reaches a minimum value at 0900 GMT (1200 GMT in December and February). The difference increases from 0900 GMT upto 1200 GMT. Th

TABLE 3

Hour of observation (GMT)	Mean value of all av. differences (R—S) in various months (°C)	Extreme values of av. differences (°C)				Extreme individual values of differences (R—S) (°C)	
		Max.	Recorded in	Min.	Recorded in	Max. (Month & Year)	Min. (Month & Year)
00	+0·5	0·7	Apr, May, Nov & Dec	0·3	Feb & Sep	3·7 (Jan 1962)	—1·1 (Nov 1960 & Apr 1961)
03	+0·9	1·5	Nov	0·4	Jul & Sep	4·0 (Oct 1960)	—2·7 (Mar 1962)
06	+0·7	1·2	Jan	0·5	Feb., Sep & Dec	4·2 (Oct 1960)	—3·0 (Mar 1961)
09	+0·5	0·8	May	0·3	Sep & Oct	3·8 (Jul 1961)	—2·4 (Nov 1960)
12	+0·3	0·5	Jan & Nov	—0·1	Feb	3·0 (Jul 1961)	—2·9 (Nov 1960)
18	+0·4	0·8	Nov & Dec	0·2	Feb	3·6 (Jan 1962)	—2·0 (Jul 1961 & Jun 1962)

situation is quite interesting during the rest of the day. The difference increases from 1200 to 1800 GMT during November and December, remains the same during January and increases again during February. During the winter season the sun rises over Calcutta before 0000 GMT and sets before 1200 GMT. It is thus seen that for about three hours from immediately after sunrise, the average value of the difference of Runway and Screen temperature (R—S) goes on increasing. In other words, the runway because of its structure and environments, becomes more heated than the observatory enclosure. With further advance of the day, the runway is losing comparatively more heat than the observatory enclosure till the minimum value of the average difference is attained at 0900 GMT. Even then, the runway temperature is slightly higher than the screen temperature. In the afternoon, the runway is gaining more heat than the observatory enclosure. As a result, the average difference of the runway and screen temperature reading goes on increasing from 0900 to 1800 GMT.

3.4.2. *Premonsoon* — During the pre-monsoon season (Fig. 2 b), the average difference between the two sets of temperature readings lies between +0·2 and +1°C. The difference is maximum (+1°C) at 0300 GMT during April and minimum (+0·2°C) at 1200 GMT during March and May.

3.4.3. *Monsoon* — During this season (Fig. 2 c), the average difference of runway and screen temperature readings lies between +0·3 and +0·7°C. The difference is maximum (+0·7°C) at 0300 GMT during June and 0600 GMT during July and August and minimum (+0·3°C) at 1200 GMT during the entire monsoon season and 1800 GMT during June and July. It is interesting to note that there is no change in the value of the difference during June at 0600 and 0900 GMT and also at 1200 and 1800 GMT and during July at 0000 and 0300 GMT and also at 1200 and 1800 GMT. It is seen that during the entire monsoon season the difference either remains constant or slightly increases during 1200 to 1800 GMT.

3.4.4. *Post-monsoon* — During the post-monsoon season (Fig. 2d), the average difference of temperature readings lies between +0·3 and +0·8°C. The difference is maximum (+0·8°C) at 0300 GMT during October and minimum (+0·3°C) at 0000 GMT during September and during 0900 to 1800 GMT during September and October. The difference remains the same between 0900 and 1800 GMT during the post-monsoon season. The difference decreases gradually from 0300 to 0900 GMT during the season.

3.5. Next, the average seasonwise values at different synoptic hours of observations have been plotted and shown in Fig. 3. In the same figure, the average values of the previous study (1963) are also superimposed. It may be seen that the result of the present study more or less corroborates the same of the previous study, the difference of values being generally of the order of 0·5°C. The maximum difference of the order of 1·0°C has, however, been found during the winter season

4. Discussion

4.1. *Effect of surface wind* — In order to study the effect of surface wind on the value of the difference of the temperature readings, the average surface winds based on different hours of observations during 1961 at Dum Dum Airport have been graphically represented in Fig. 4. It is seen that the surface winds are generally less than 5 km/hr during the winter months. When the surface winds are fairly strong, there would be turbulent mixing of the air close to the ground and the difference of temperature readings over the two spots of observation may not be appreciable. When the winds are comparatively calm, the air in the vicinity of the observation spots would be relatively stagnant and this might result in the difference of temperature readings. One of the reasons of the higher values of average difference in the temperature readings (more than 1°C) obtained during the winter months may be due to relatively calm surface wind conditions prevailing in this period.

4.2. *Radiation effect* — Apart from the surface wind there are other reasons for the difference of temperature of air near the ground. One of the reasons may be the radiation effect due to the difference in the structure of the observation spots, as suggested by Angstrom (1928), Moller (1936), Pasquill (1949), Sutton (1953) and Homen (1897). The condition of exposure to the observation site may also have some effect on the difference of temperature readings. This effect may not, however, be appreciable, because in both the sites, free air circulation was available.

5. Concluding Remarks

From the above discussion, the following salient features are brought out —

(*i*) The average value of runway temperature is generally higher than that of the screen temperature except at 1200 GMT during February.

(*ii*) The average difference of the two sets of temperature observations are generally less than 1°C except at 0300 GMT during January, February, April, November and December and 0600 GMT during January.

(*iii*) On individual occasions, the runway temperature may either be higher or lower than the screen temperature, the maximum difference being 4°C. The maximum value of the difference has been found to be +4·2°C on an occasion at 0600 GMT in October 1960 and the minimum —3·0°C at 0600 GMT in March 1961.

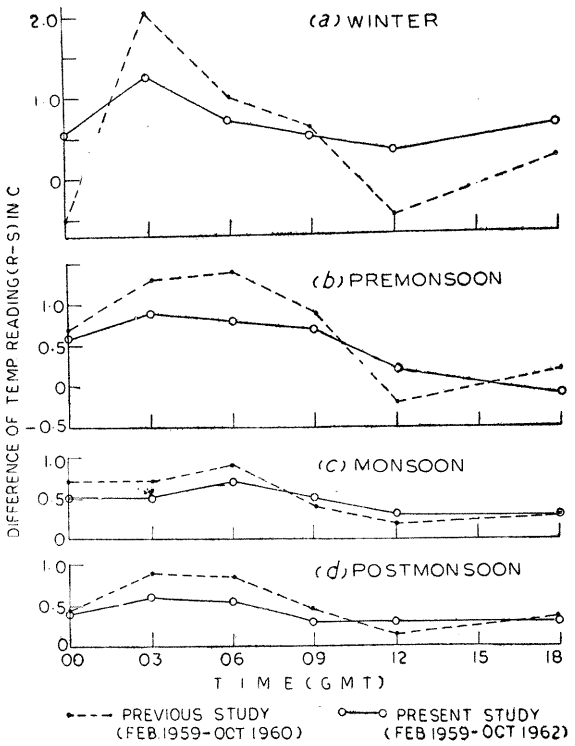

Fig. 3

Curves showing the average seasonwise values of differences of runway and screen temperature observations at different synoptic hours. Average values of the previous study are also superimposed

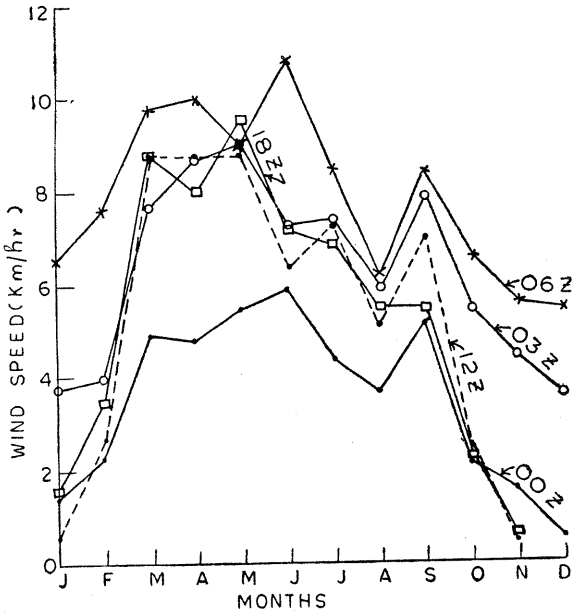

Fig. 4

Curves showing the variation of surface wind against months of the year in respect of Dum Dum Airport for the year 1961

(*iv*) The average difference of the temperature readings is maximum in November and minimum in February. The higher range of variation during the winter months may be attributed to the effect of weak surface wind prevailing during the season.

(*v*) One reason of the difference may be due to radiation effect consequent upon the difference of the structure of the observation spots.

REFERENCES

Angstrom, A.	1928	*Meddn. St. met-hydrogr. Aust.*, **4**, 3.
De, A. C.	1963	*Indian J. Met. Geophys.*, **14**, 4, pp. 441-446.
Homen, Th.	1897	"*Der tagliche warmeumsatz in Boden USΨ*" Leipzig.
Moller, F.	1936	*Beitr. Geophys*,, **47**, 215.
Pasqill, F.	1949	*Proc. R. Soc., A.* **198**, 116.
Sutton, O. G.	1953	*Micrometeorology*, Chap. 5 & 6.