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The temperature field in the lowest layers of the atmosphere over Poona

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ABSTRACT. Temperatures at two levels (1·2 metres a. g.l. and 36·58 metres a.g.l.) for the two random years 1949 and 1957 are analysed. Unstable thermal stratification during day time due to turbulence and eddies changing over to stable thermal stratification due to nocturnal cooling of the air layers and consequent inversion has been described high-lighting their time of occurrence and month to month variation.

Temperature variations for the year 1949 at the two levels have also been subjected to harmonic analysis.

1. Introduction

The diurnal variation of temperature in the layers of the atmosphere near the ground is not only of meteorological importance but has also a direct bearing on many aspects of plant and animal life. In recent years, the problem of air pollution resulting from rapid industrialization, particularly in densely populated urban areas is drawing considerable attention to the study of the meteorological conditions of the lowest layers of the atmosphere. A number of industrial establishments have sprang up in and around Poona during the past two decades. In this context the study reported in this paper would be of interest.

2. Data

The study is based on the analysis of the data recorded by thermographs at two different elevations in the Meteorological Office at Poona. One of these instruments was inside a Stevenson screen in the observatory enclosure at the standard elevation of 1.2. m.a.g.1.; the other was inside a similar screen on the top of the observatory tower at an elevation of 36.58 m.a.g.l. The observations at the two locations were made for nearly three decades, commencing around 1930. Although a large volume of data were collected, they have not been analysed. Hence, it was considered worthwhile to examine the hourly data of temperature.

3. Analysis of the data

Utilising the hourly tabulations from the thermograms a comparative study of the diurnal variations in the stability of the thermal stratification of the atmospheric layer between the two locations have been attempted in this paper. After a preliminary examination of the available records, the years 1949 and 1957 for which data were complete, were selected for the present study.

The following parameters were computed :

(*i*) Monthly mean values of hourly temperatures at the two locations.

(*ii*) Hourly change of temperature for each day at the two locations.

(*iii*) Difference in temperature at the same hour at the two locations for each day.

(*iv*) Monthly mean values for parameters (*ii*) and (*iii*) above (Despite the large scatter in the values for the individual days, the monthly mean values were fairly consistent in the two years).

The monthly mean values of the hourly temperatures at the two locations for the year 1949 were further subjected to harmonic analysis.

4. Results and conclusions

The mean diurnal variation of temperature difference between tower and enclosure for the four representative months — January, April, July and October — are shown diagramatically in Fig. 1 for the combined data of 1949 and 1957.

(*a*) *Temperature difference between tower and enclosure*

Examination of the temperature differences between the two locations shown graphically in Fig. 1, brings out that the unstable thermal stratification which prevail during the day, change over to stable stratification by sunset in all the months. However, the nocturnal cooling of the

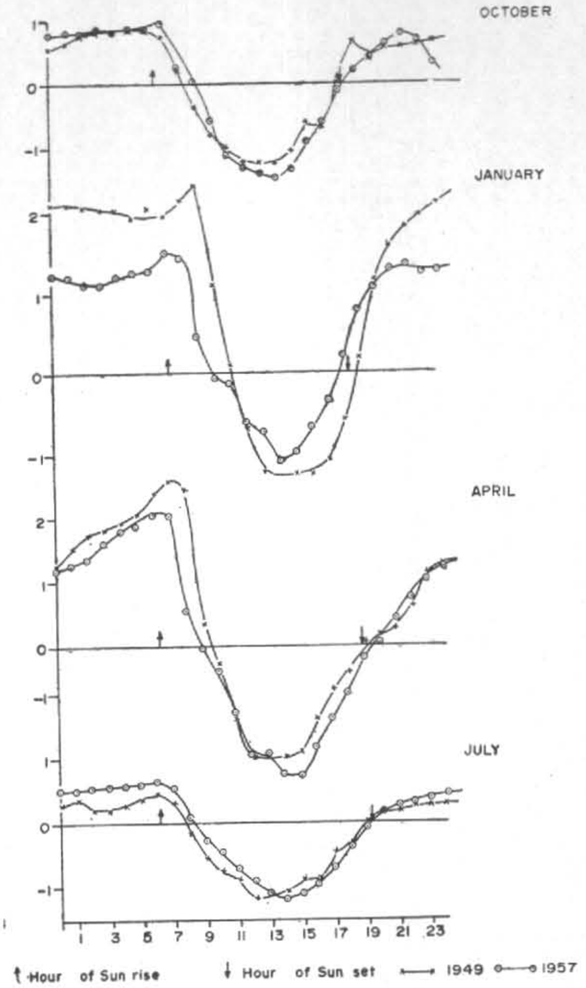

Fig. 1. T—E

air layers close to the ground and the low level inversions are very much more pronounced in the months October to May when clear skies and low humidity conditions prevail as compared to the monsoon months June to September which are cloudy and humid.

The change over of the stable to unstable stratification which occurs with the break up of the nocturnal inversion after sunrise, takes place between 09 and 10 hours in December, January and February; it occurs between 08 and 09 hours in March, April, September, October and November; from May to August the change over to unstable thermal stratification occurs between 07 and 08 hours. In the evening the change to stable condition occurs by about 17 hours in the winter months and between 19 and 20 hours in the summer and monsoon months. Thus stable thermal stratification of the lowest layers prevails for nearly 16 hours in a day in the post monsoon and winter months and for about 12 hours in the other months.

The magnitude of difference in temperature between the two levels are the largest — negative or positive — corresponding to the peak of unstable or stable conditions.

The differences are smallest at the time of change over from one condition to other. The period between the time of occurrence of the largest positive difference to the time when the difference is zero is the period of turbulent mixing for the intervening layer.

The magnitude of differences are generally larger in January and April than in July and October. From the period of turbulent mixing for the two years no definite conclusion can be drawn about the seasonal trend. The period of turbulent mixing varies from 1 hr 48 min (July 1949) to 3 hr (January 1957).

(b) *Rate of change of temperature*

Fig. 2 represents the rate of change of temperature from hour to hour at each level. To obtain the

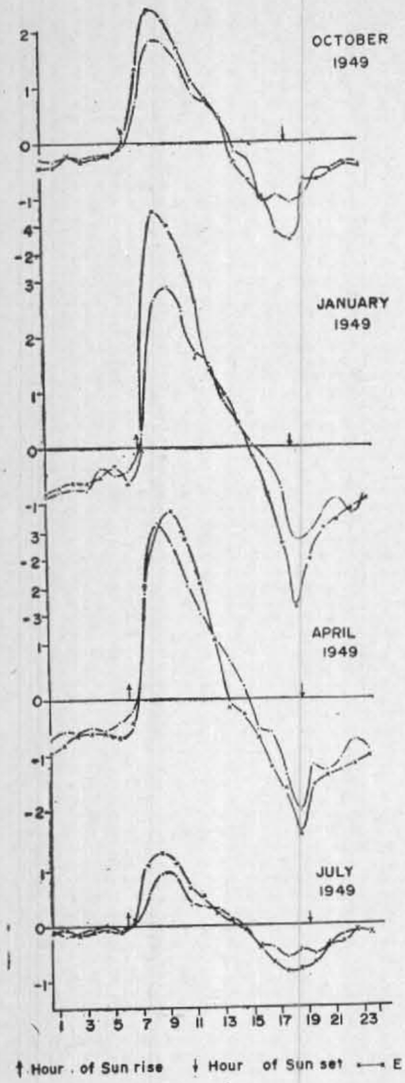

Fig. 2(a)

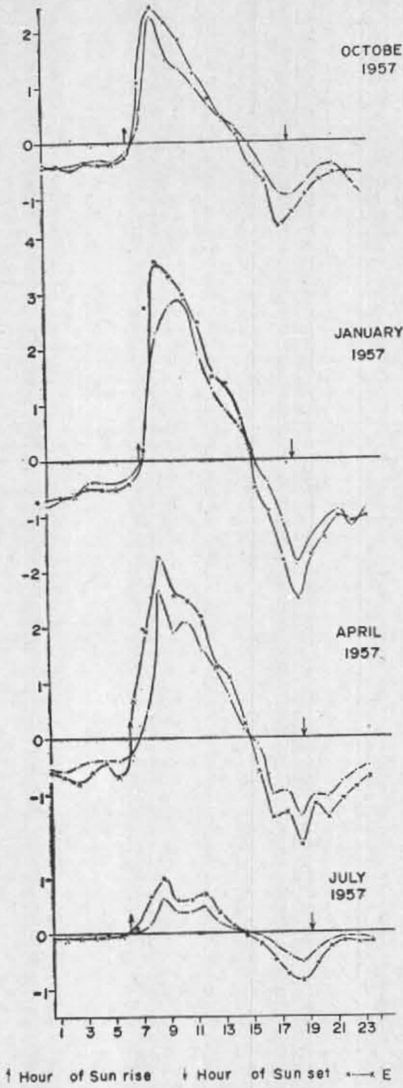

Fig. 2(b)

rate of change, each hourly temperature is subtracted from the suceeding hourly temperature.

Figs. 2(a) and 2(b) show graphically the diurnal variation of hourly rate of change of temperature at the two elevations for the year 1949 and 1957. The hours of sunrise and sunset for Poona for the middle day of each month are also shown in the diagram by arrows. It is seen that large changes in temperature occurs near about the time of change over from stable to unstable conditions or *vice versa*. The changes are most pronounced in January and least in July.

(c) *Harmonic analysis of mean hourly temperature in the months of January, April, July and October 1949*

Fig. 3 represents the first and second harmonic together with the actual monthly means of hourly temperatures at the tower and in the enclosure, for the four representative months, January April, July and October of 1949. The amplitude and phase angle of the harmonics are given in Table 1.

It can be seen that

1. (*i*) First harmonic (diurnal) and second harmonic (semi-diurnal) together account for almost all (99%) the fluctuations.

(*ii*) First harmonic itself accounts for almost (93% to 87% in the enclosure and 95% to 89% for tower) all the fluctuations.

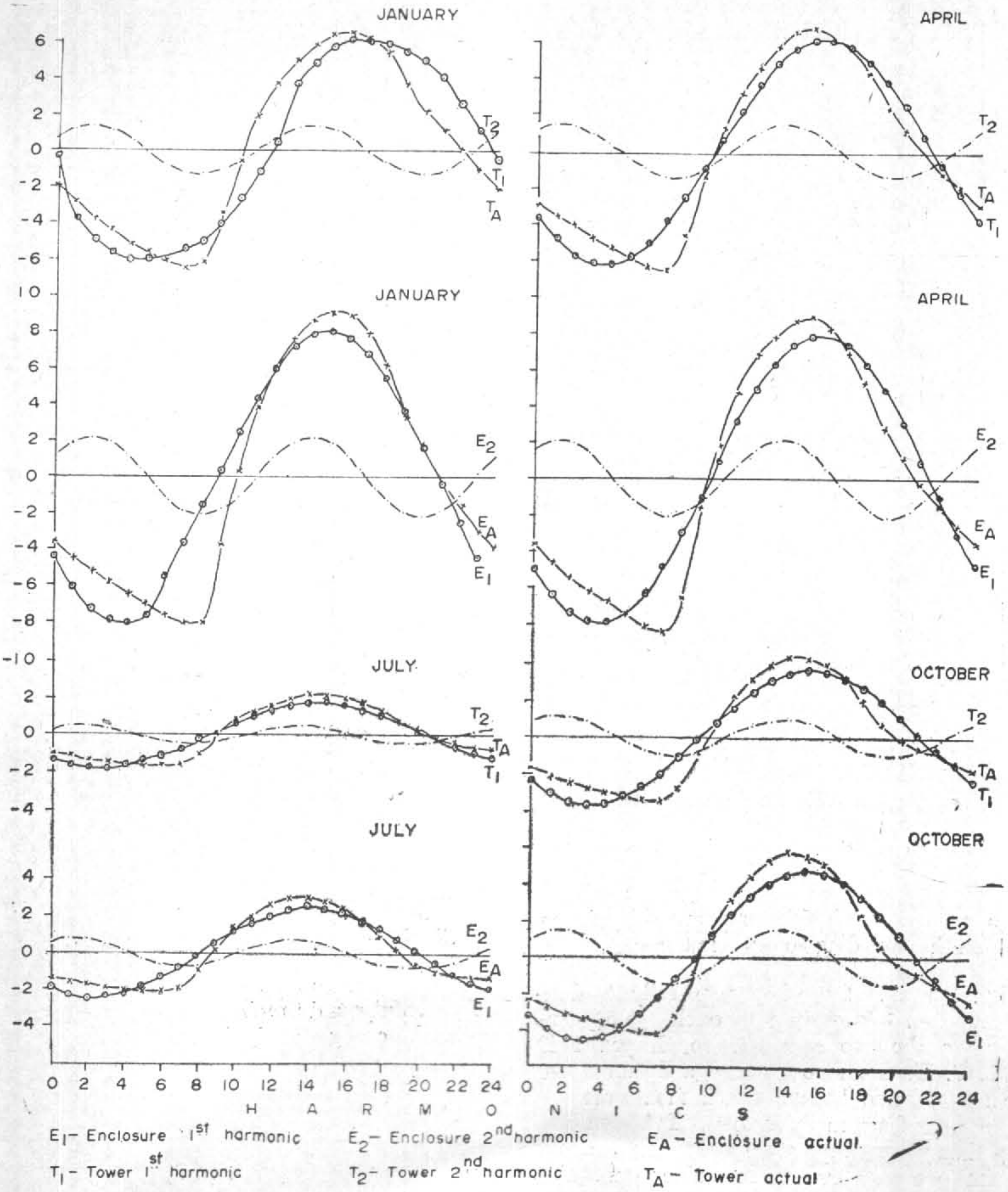
JANUARY
APRIL
JULY
OCTOBER
T2
T1
TA
E2
EA
E1
H A R M O N I C S
E1 – Enclosure 1st harmonic
E2 – Enclosure 2nd harmonic
EA – Enclosure actual
T1 – Tower 1st harmonic
T2 – Tower 2nd harmonic
TA – Tower actual

Fig. 3

TABLE 1

	First Harmonic				Second Harmonic				% variation accounted by the harmonics				Mean time of occurrence of max.		Occurrence of time of max. amplitude of the 1st harmonic		Difference in time of occurrence of max. amplitude of the 1st harmonic at Tower & Enclosure
	Enclosure		Tower		Enclosure		Tower		First Hermonic		Second Harmonic						
	Aplitude (°C)	Phase angle	Amplitude (°C)	Phase angle	Amplitude (°C)	Phase angle	Amplitude (°C)	Phase angle	Enclosure	Tower	Enclosure	Tower	Enclosure	Tower	Enclosure	Tower	
Jan	8·1	213·3	6·1	204.1	2·2	30·8	1·4	33·1	91·7	94·4	6·9	4·7	1500	1500	15·8	16·4	·6
Feb	9·2	211·8	6·9	206·2	2·2	37·4	1·5	44·9	93·1	93·8	5·4	4·3	1600	1600	15·9	16·2	·3
Mar	8·9	211·3	6·7	208·9	2·2	45·3	1·6	44.9	92·6	92·9	5.9	5·6	1500	1500	15·9	16·1	.2
Apr	8·0	217·7	6·2	216·5	2·2	51·4	1·5	47·5	92·0	93·4	6·6	5·4	1500	1500	15·5	15·6	·1
May	5·4	229·0	4·3	226·6	1·8	50·1	1·3	43·9	89·5	91·1	9·9	8·5	1400	1400	14·7	14.9	·2
Jun	3·6	233.7	2·7	229·0	1·0	51·5	·7	48·9	91·8	92·3	7·6	7·1	1400	1400	14·4	14.7	·3
Jul	2·5	236·4	1·8	231·0	·8	52·6	·5	50·1	89·9	91·2	8·9	7·7	1300	1400	14·2	14·6	4
Aug	2·6	233·6	2·0	230·6	·9	50·6	·6	44·4	79·2	90·7	10·1	8·9	1400	1400	14·4	14.6	·2
Sep	2·6	236·9	1·9	231·9	·9	58·4	·7	52·9	87·6	88·7	11·5	10·6	1300	1400	14·2	14·5	·3
Oct	4·7	225·7	3·7	222·2	1·5	44·8	1·1	42·9	89·7	90·8	9·4	8·4	1400	1400	14·9	15·2	·3
Nov	7·6	219·3	5·8	210·6	2·1	46·8	1·1	40·5	90·9	94·9	7·5	3·7	1500	1600	15·4	15·9	·5
Dec	8.9	215·8	6·7	206·9	2·5	37·7	1·5	34·1	91·5	94·0	7·4	4·5	1500	1600	15·6	16·2	·6

2. (*i*) Time of maximum amplitude of 1st harmonic always occurs earlier at enclosure (14.2 hr to 15.9 hr) than at tower (14.5 hr to 16.4 hr).

(*ii*) The time of occurrence of maximum amplitude at the tower lags by 6 min (0.1 hr) during the months of April and by 36 min (.6 hr) during December and January. This shows that low level turbulence and eddies are more active during April than during December and January. A period of higher activity also indicated in August by the secondary minimum of time lag as seen from Table 1.

3. The amplitudes of 1st harmonic of temperature variations in enclosure are larger than those at the tower in all the months. The largest amplitudes for both at the tower and in the enclosure occur during the month of February (9.2° and 6.9°C).

The amplitudes of the second harmonic of temperature variation in the enclosure are higher than those at the tower. The amplitude is the largest at both the levels during December (2.5° and 1.5°C) and smallest during July (.8°C and . 5°C).

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