

551.524.2 : 719 (545.5)

ISOTHERMAL AND ISOHYETAL PATTERNS AT DELHI AS A SEQUEL OF URBANIZATION

Earlier the authors (Bahl and Padmanabhamurty 1979, Padmanabhamurty and Bahl 1980) have presented the isothermal pattern at Delhi in winter based on mobile temperature surveys. Although these surveys indicate the location and intensity of heat islands on a particular night, they do not present the day-to-day and diurnal variations. To obtain this, it is necessary to have a network of permanent observatories in and around an urban area. At Delhi the network was initiated in 1971 but gained impetus only in 1976. The number of observatories in Delhi were 11 in 1976, 18 in 1977, 20 in 1978, 18 in 1979 and 22 in 1980. The daily maximum and minimum temperatures recorded at each of these observatories in each month are averaged over the years of data available and analysed for obtaining the heat island intensities. In the present paper the variations of the heat island at maximum and minimum temperature epochs, the effect of onset and withdrawal of monsoon on the isothermal pattern, the effect of thunderstorms and duststorms on heat island intensities and the precipitation zones are presented and discussed.

2. Mean isotherms at maximum temperature epoch —

Mean heat island intensities at maximum temperature epoch monthwise at Delhi are given in Table 1.

The maximum intensity of the heat island of 4 deg. C occurred in winter. The monsoon season (June-Sept) exhibited a uniform heat island intensity of 2 deg. C. In the pre-monsoon or post-monsoon they are higher than monsoon months.

2.1. Mean isotherms at minimum temperature epoch — Monthwise heat island intensities at minimum temperature epoch are also given in Table 1.

Maximum intensity of 6 deg. C occurred in the winter months of October to March except February and minimum occurred in monsoon months. Either in post-monsoon or pre-monsoon months the intensities are higher than in monsoon.

3. Rainfall distribution at Delhi — Rainfall distribution in Delhi from June to September points out that pockets of higher rainfall existed in all months; being intense in July/August. These pockets of higher rainfall correspond to the congested urban agglomeration supporting the hypothesis of Changnon (1969, 1980) that urbanization leads to increased precipitation (Figs. 1 and 2).

4. Temperature pattern at onset/withdrawal of monsoon — Temperature pattern prior, on the day and after the onset and withdrawal of monsoon during the years 1976-1978 at maximum temperature and minimum temperature epochs has been studied. The steady state conditions before, during and after the cessation of the monsoon onset and withdrawal, duststorms and thunderstorms are presented in Table 3. The temperatures have generally been observed decreasing after onset as well as withdrawal of monsoon.

TABLE 1

Mean heat island intensities ($^{\circ}$ C) at (a) maximum and (b) minimum temperatures epoch at Delhi

Month	Heat island intensity ($^{\circ}$ C)		Month	Heat island intensity ($^{\circ}$ C)	
	Max.	Min.		Max.	Min.
Jan	4	6	Jul	2	5
Feb	3	4	Aug	2	4
Mar	4	6	Sep	2	3
Apr	3	6	Oct	4	6
May	4	5	Nov	2	6
Jun	2	3	Dec	3	6

TABLE 2

Intensities ($^{\circ}$ C) of heat island at maximum and minimum temperature epochs

Year	At max. temp. epoch			At min. temp. epoch		
	Prior	On the day	After	Prior	On the day	After
(a) Onset of monsoon						
1976	4	8	4	1	3	2
1977	3	4	4	5	5	5
1978	8	6	3	4	4	2
(b) Withdrawal of monsoon						
1976	4	5	7	4	3	6
1977	7	4	3	5	8	6
1978	2	2	3	3	3	3
(c) Days of duststorms						
17 Apr 78	8	7	4	8	8	10
31 May 78	10	4	4	4	4	3
5 Jun 78	2	2	2	4	4	5
(d) Days of thunderstorms						
17 Feb 78	7	4	10	5	4	8
30 Mar 78	8	6	7	8	8	7
28 Apr 78	6	4	3	9	5	5
7 May 78	3	3	1	5	6	6
24 Jun 78	7	3	3	3	6	4
12 Jul 78	5	2	7	3	2	4

The intensities of heat islands observed prior, on the day and after the onset and withdrawal of monsoon at maximum and minimum temperature epoch during the years 1976-1978 are also given in Table 2.

5. Temperature pattern on the day of duststorms — A few duststorms occurred during 1978 have been studied to understand their effect on the temperature pattern at maximum and minimum temperature epoch before and after their occurrence. Steady state conditions prior, during and after the duststorms are given in Table 3. The heat island intensities at maximum temperature epoch are decreasing on the day of duststorms and thereafter, than compared to before duststorm. At minimum temperature epoch heat island intensities are decreasing on the day of duststorm than before, but after the duststorm it is sometime decreasing and sometimes increasing.

The heat island intensities observed prior, on the day and after occurrence of some duststorms in 1978

TABLE 3
Steady state conditions prior, during and after the occurrence of various phenomena

DATE	TIME OF COMMENCEMENT (IST)	WEATHER REMARKS
ONSET OF MONSOON		
11 JUL 76	0300	R 0300 < 0300 • 0545 R 1000, 1200 V 1920 • 1922 < 2010
29 JUN 77	1322 ON 28 JUN 77	R 0330 < 0410
30 JUN 78	0250	S 0250 • 0250 • 0725 < 1530 < 1943 0310 < 1740 < 2015
WITHDRAWAL OF MONSOON		
20 SEP 76	---	---
26 SEP 77	---	---
27 SEP 78	---	0825 < 1810 < 1945
DUSTSTORMS		
17 APR 78	2220	S 0000 0550 • 0602 < 0920 (2155 • 2220 • 2220 0550 0645 < 0920 CONT 2221 • 2250
31 MAY 78	1838	S → S 1838 < 1838 V 1903 < 1920 1920 V 1908
5 JUN 78	1100	S → S 0740 < 0740 < 1100 < 1215 < 1320 1100 < 1215 < 1320 S 1320
THUNDERSTORMS		
17 FEB 78	0350	S 0350 R 0350 R 0400 R 0512 < 0600 < 0625 0730 < 1428 0515 R 0600 < 0625 1015 R
		V 1448 R 1450 R 1605
30 MAR 78	2155	< 0100 < 0620 < 0720 < 2120 < 2155 < 2215 < 2230 0720 < 2120 < 2155 R 2215 < 2232 2310
28 APR 78	1935	S 1900 S 1905 < 1905 < 1922 < 1935 < 2040 < 2205 • 2205 2040 < 1924 < 2040 < 2205 < 2205 < 2208 S 2208 2248
7 MAY 78	1815	S → S 1815 R 1815 V 1825 < 2030 < 2030 1826 R 2030 < 2100 S →
24 JUN 78	0345	• 0315 R 0345 V 0615 < 0700 < 0225 < 2000 < 2109 < 2120 0616 < 1025 < 1100 < 2000 < 2109 R 2120
12 JUL 78	1355	R 1355 < 1825 S 1930 < 2045 1520 1835 < 2045

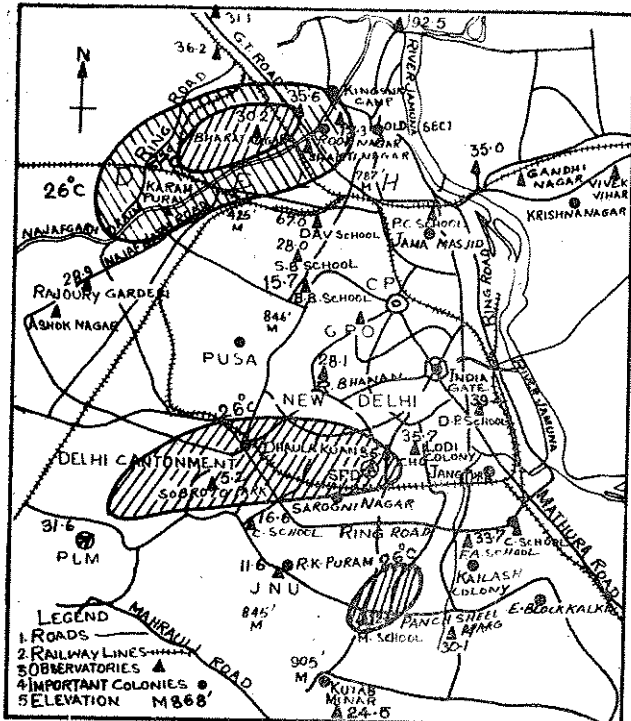


Fig. 1. Mean monthly rainfall (cm) at Delhi for July (Hatched areas represent heat islands/warm pockets)

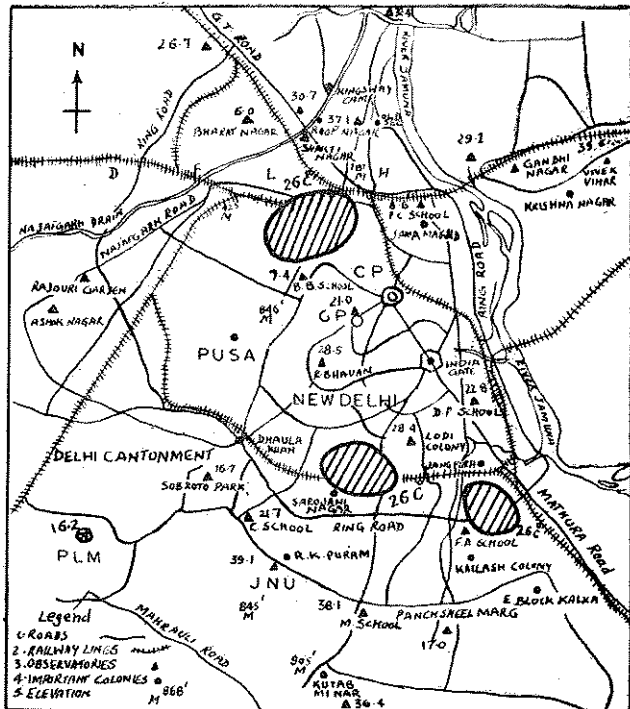


Fig. 2. Mean monthly rainfall (cm) at Delhi for August (Hatched areas represent heat islands/warm pockets)

at maximum and minimum temperature epochs are also shown in the Table 2.

6. *Temperature pattern on the days of thunderstorms* — Six thunderstorms which occurred in Delhi between Feb. and July '78 have been studied and isotherms drawn before and after their occurrence. Steady state conditions prior, during and after the occurrence of phenomena are given in Table 3. Heat island intensities at maximum temperature epoch have been mainly decreasing on the day of occurrence of thunderstorm and after the occurrence it is generally increasing whereas at minimum temperature epoch it is either decreasing or same or even increasing on the day and after occurrence of thunderstorm.

The heat island intensities observed prior to, on the day and after the occurrence of the above six thunderstorms in 1978 at maximum and minimum epochs are shown in Table 2.

References

Bahl, H.D. and Padmanabhamurty, B., 1979, 'Heat island studies at Delhi', *Mausam*, 30, pp. 119-122.

Changnon (Jr.), S.A., 1969, 'Recent studies of urban effects on precipitation in the United States', *Bull. Am. Met. Soc.*, 50, 411.

Changnon (Jr.), S.A., 1980, 'More on the La Ports Anomaly, A Review,' *Bull. Am. met. Soc.*, 61, 7, 702-711.

Landsberg, H.E., 1956, '*The climate of Towns*' in *Man's Roles in Changing the Face of the Earth*, Chicago, Illinois University of Chicago Press, pp. 584-606.

Padmanabhamurty, B. and Bahl, H.D., 1980, 'On the surface structure and movement of heat and humidity islands at Delhi', Presented at the International seminar on the 'Management of Environment' at BARC, Bombay, February.

Padmanabhamurty, B., 1980, 'Man induced climatic change, Paper presented at the All India Seminar on 'Nature Protection and Modern Society' held at Max Muller Bhavan, Bombay, 20-21 November.

B. PADMANABHAMURTY
H. D. BAHL

Meteorological Office, New Delhi
6 January 1982