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Diurnal variation of mean mixing depths in different months at Delhi

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सार – दिल्ली शहर के लिए विभिन्न महीनों में मिश्रण गहराई का औसतन दैनिक विचरण पांच साल के आंकड़ों के आधार पर निकाला गया है। विभिन्न ऋतुओं के प्रतिनिधि चार महीनों के लिए दैनिक विचरण के परिणामों को मानक विचलन के साथ ग्राफ पर दिखाया गया है। अन्य शोधकर्ताओं द्वारा आकलित मिश्रण गहराइयों से तुलना करने पर यहां प्राप्त परिणाम भी पर्याप्त मिलते-जुलते प्रतीत होते हैं।

ABSTRACT. Based on five years data, mean diurnal variation of mixing depth in different months over the year for the city of Delhi have been estimated. Results of the diurnal variation is graphically shown with the standard deviation for the four representative months of the seasons. A good agreement has been found in comparison with the mixing depths estimated by other authors.

1. Introduction

A study of dispersion parameters for the city of Delhi, with the help of meteorological parameters is being attempted. One of the important parameters which was found essential for this approach is the diurnal variation of the depth of boundary layer or mixing depth for all the twelve months of the year. So far, the diurnal variation of mixing depth has been presented by Padmanabhamurty and Mandal (1976) for six winter months, October 1975 to March 1976, for Delhi. Results are graphically available only for the month of Jan. 1976. Based on five-year data, the present study obtains mean monthly diurnal variation of the mixing depth for the city of Delhi, over the whole year. According to Shukla (1981), the variance of climatological mean is smaller for tropics than for mid-latitudes. Therefore, climatological mean monthly diurnal variation of mixing depths obtained from monthly mean is likely to give good estimates of the diurnal variation of mixing depths.

2. Procedure

Method of Holzworth (1967) has been used for the estimation of mixing depths. To take into consideration, the pressure differences with the sea level, tephigrams have been used to estimate the same. Ten-year (1958-76) climatological mean surface temperatures (Mani 1980) have been used. Urban heat island intensities have been incorporated into surface temperatures from the available three sources :

(1) Krishnanand and Maske (1981), (2) Koteswaram (1981) and (3) Padmanabhamurty and Bahl (1982), and mixing depths, so obtained were plotted (Fig. 1). Mixing depth from sources (1) and (3) shows similarity in its pattern and magnitude. The values of the mixing depths obtained through source (2) were found to be very high.

For the present study, heat island intensities obtained by Krishnanand and Maske (1981) have been found most suitable as it represents mean monthly mixing depths for the ten months and gives a reasonable estimates of mixing heights. Due to non-availability of the same for the month of October and November alternate methods were used.

Mixing depths for the four months, December 1971 and 1972 and May and June 1971, could not be calculated because the surface temperatures were colder than the surface temperature from RS observations and Holzworth's technique could not be applied.

3. Discussion

As expected, the mixing depth increases from a minimum in the morning to a maximum around 15 IST and decreases thereafter. This response is clearly due to the diurnal variation in surface temperature. Figs. 2 (a-d) show the diurnal pattern with the standard deviation for four representative months of the seasons. Winter months are characterised by low values of mixing depths, *e.g.*, December (Table 1) shows the minimum value of both the maximum and minimum mixing depth. Summer month shows comparatively high value of maximum mixing depth among all the twelve months. Monsoon months show high values of morning depths and comparatively low values of after-

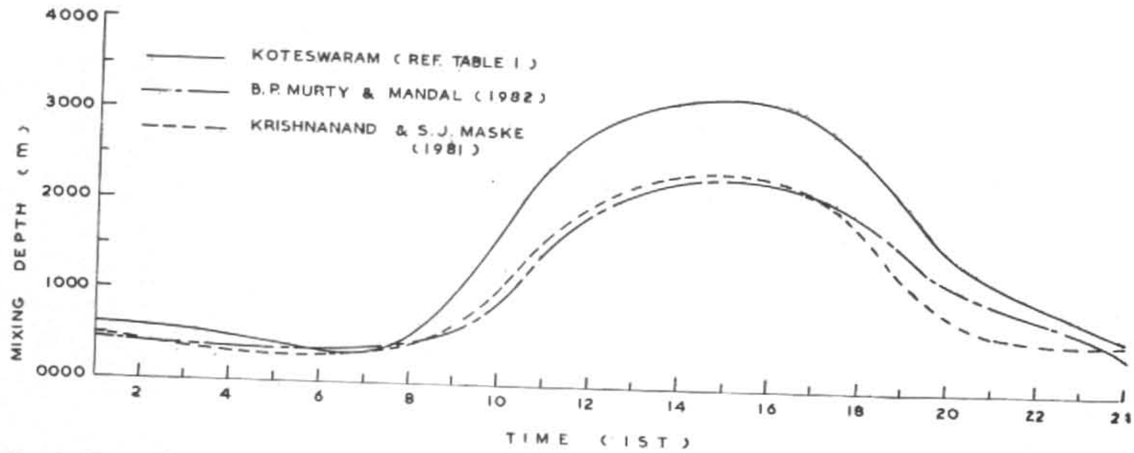
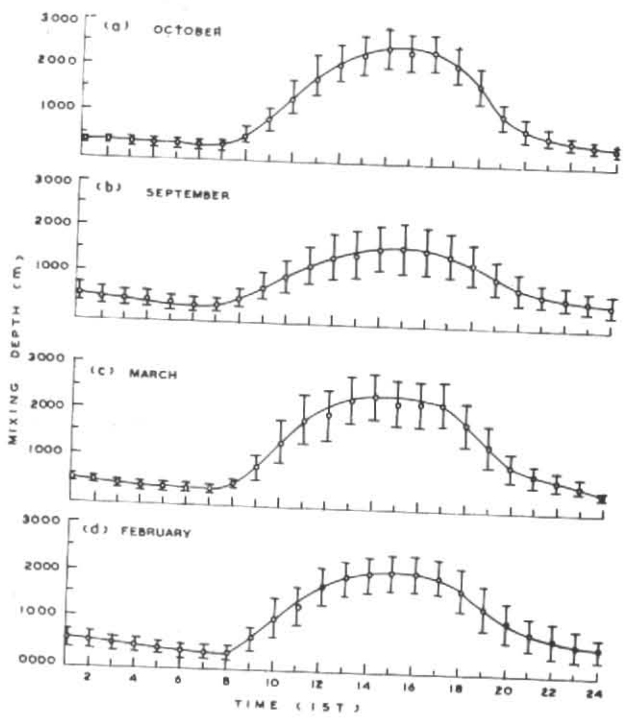


Fig. 1. Comparison of the mixing depths obtained from three different heat island intensities for March 1972



Figs. 2(a-d). Diurnal variation of mean (1968-72) monthly mixing depth for the four representative months (Oct, Sep, Mar and Feb) of the seasons

TABLE 1

Camparison of the minimum and maximum mixing depths

Month	Minimum mixing depth (m)			Maximum mixing depth		
	Present study	Paper I*	Paper II*	Present study	Paper I*	Paper II*
			Present study			
Oct 1970	270	85		2436	2550	
Nov 1970	137	50		1901	2050	
Dec 1970	34	40		1115	1300	
Oct 1971	337	100		2385	2240	
Nov 1971	118	70		1895	1730	
Dec 1971	—	—		—	—	
Jan 1971	168	90		1763	1370	
Feb 1971	201	100		1873	1550	
Mar 1971	341	70		2768	2570	
Oct 1972	269	100		2961	2400	
Nov 1972	35	50		1795	1600	
Dec 1972	—	—		—	—	
Jan 1972	41.5	60		1289	1160	
Feb 1972	445	110		2580	1660	
Mar 1972	309	100		2321	2230	
			Averages*			
Jan	99	85	100	1420	1440	810
Feb	296	109		2134	1710	
Mar	307	80		2405	2450	
Apr	157		500	2856		2450
May	154			2771		
Jun	300			2791		
Jul	443			1703		
Aug	441		150	1465		850
Sep	328			1666		
Oct	297	90	50	2422	2440	900
Nov	126	20		1789	1810	
Dec	97	50		1026	1350	

Paper I*—Murty and Mandal (1976, 1979),
Paper II*- Vittalmurty *et al.* (1981)
Averages*—

(*i*) Present study contains five year (1968-72) averages of maximum and minimum mixing depths for twelve months of the year.

(*ii*) Paper I contains seven-year (1970-77) averages of max. and min. mixing depths for six months(Oct-Mar) of the year.

(*iii*) Paper II contains five-year (1959-63) averages of max. and min. mixing depths for four representative months (Jan, Apr, Aug and Oct) of the seasons.

noon mixing depths, *e.g.,* July (Table 1) shows the maximum value of morning mixing depth. Partially, it could be attributed to the cloudiness during the season and the lack of consideration of moisture content in the analysis technique.

Diurnal variation of mixing depth shows asymmetry around the maximum mixing depth, *i.e.,* the rate of rise in mixing depth before noon is slower than the rate of fall of mixing depth afternoon. January shows maximum asymmetry among winter months and June shows maximum asymmetry among the summer and monsoon months. March is a symmetric month.

In general, radiational heating and cooling may play an important role in the asymmetry mentioned above. The particulates and aerosols present in the environment back scatters significant amount of solar energy during the daytime and therefore, delay the attainment of maximum surface temperature. While considering the transmission of longwave radiation (night time) through the atmosphere the same particulate matter does not allow much of the long wave radiation and also contributes the counter radiations. Thus, the radiational heating and cooling effects, to analyse the aforementioned asymmetries in the different months.

Results of the present study have been compared with the available months and year of the mixing depths obtained by Padmanabhamurty and Mandal (1976, 1979) hereinafter referred as paper I and Vittalmurty *et al.* (1981) hereinafter referred as paper II. Results of the studies and their comparison is presented in Table 1.

In general, morning mixing depths of present study have been found to be quite higher than paper I and afternoon mixing heights were found to be slightly higher than paper I. The reasons for the same can be given as below :

(*i*) Ten-year (1958-67) climatological mean surface temperatures have been used in the present study which could be higher than the surface temperatures of the years under comparative study.

(*ii*) Minimum 5 mb pressure can be read accurately on a tephigram and a difference in 5 mb can cause a maximum difference of 100 m in mixing depths.

3 (a). The use of a different nocturnal urban heat island effect (which is the basis of morning mixing depth) in the present study, than the other studies may lead to the different morning mixing heights.

3 (b). The use of 1 deg. C as the effect of urban heat island at maximum temperature epoch for all the twelve months following Krishnanand and Maske (1981) leads to a somewhat higher maximum depths than the other studies.

4. Conclusions

Based on five years data, diurnal variation of the mean mixing depths in different months has been estimated for the city of Delhi over the whole year. Results are discussed and compared with the measurements by the other authors.

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