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ESTIMATION OF ROUGHNESS LENGTH AT KHARAGPUR MICRO-METEOROLOGICAL TOWER SITE DURING MONSOON ONSET OF 1990

1. It is well-known that within the surface layer of atmospheric boundary layer, the vertical profiles of wind velocity and potential temperature have the following relationships :

$$u(z) = \frac{u_*}{k} \ln (z/z_0) \qquad (1)$$

and

$$\theta(z) - \theta_0 = \frac{\theta_*}{k} \ln (z/z_0) \qquad (2)$$

in thermally neutral condition. The various symbols have their usual meaning.

Hereby the value of z_0, the roughness length, is being estimated at Kharagpur (22.30° N, 87.20° E). This value is obtained from the data taken during the onset phase of monsoon 1990.

2. *Data* — Of the four micrometeorological towers each of 30 m height with six levels of instrumentations at 1, 2, 4, 8, 15 and 30 m height one tower was set up at Kharagpur during the MONTBLEX in 1990. The terrain of tower site was flat with small grass. Temperature and wind velocity sensors were located at all six levels. But as the temperatures at 4 and 8 m levels show a very sharp variation, these temperatures were ignored in the present study.

In the present study only slow response data recorded on a Campbell data logger at a frequency of 1 Hz and provided as 3 min average are used. Ten days data during the onset phase of nonsoon from 27 May 1990 to 10 June 1990 are utilised. Some of the days are not being considered as the data files during the transition from stable to unstable thermal situation and *vice-versa* are not available.

3. *Method and results* — It is known that $\partial\theta/\partial z$ vanishes in thermally neutral condition. So for the identification of neutral or near-neutral situation, one can look for the situation where the gradient $\partial\theta/\partial z$ takes a minimum value either on positive or negative side.

So, one can plot θ-ln z profile at various times and can note the time where the gradient takes a minimum value. For the consideration of wind profile, one can also utilise two other times at 3 min interval on either side of the noted time.

From Eqn. (1), it is obvious that u-ln z curve will be a straight line in neutral situation. z_0 is evaluated using Eqn. (1) only. Incidentally it happens in the present data set that at identified thermally near neutral time the data set for u-ln z curve are evenly distributed around the best fitting straight line as well as scatter is very small (Fig. 1). Whereas at other two instants surrounding the noted time, the scatter is distinctly more. The departure from linearity in Fig. 1 is small enough to be attributed to pure randomness. Hence one can now utilise Fig. 1 for the estimation of z_0 following Eqn. (1).

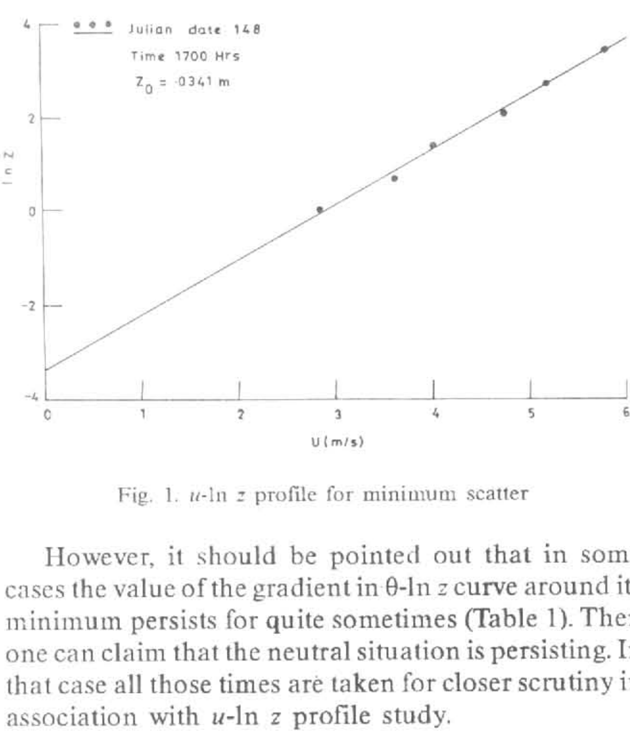

Fig. 1. u-ln z profile for minimum scatter

However, it should be pointed out that in some cases the value of the gradient in θ-ln z curve around its minimum persists for quite sometimes (Table 1). Then one can claim that the neutral situation is persisting. In that case all those times are taken for closer scrutiny in association with u-ln z profile study.

In case the double identification is not possible, the near neutral situation identification becomes suspect. That case is being rejected. So taking help of both the Eqns. (1) and (2), one can precisely identify the near neutral situation. Besides, only the smooth thermal transitions are being considered. There are instances of rapid fluctuation of θ-ln z gradient with time between positive and negative values. Such instances have been ignored and only cases of transition from persistent positive gradient to persistent negative gradient and *vice-versa* have been taken into account.

TABLE 1

Julian date-148

Morning		Evening	
Time (hr)	$\frac{\partial\theta}{\partial \ln z}$	Time (hr)	$\frac{\partial\theta}{\partial \ln z}$
05.25	0.0770	16.45	—0.0876
05.30	0.0679	16.50	—0.0881
05.35	0.0623	16.55	—0.0709
05.40	0.0484	*16.60	—0.0019
05.45	0.0432	*16.65	—0.0101
05.50	0.0376	*16.70	—0.0001
05.55	0.0241	*16.75	—0.0048
05.60	0.0154	16.80	—0.0220
*05.65	0.0041	16.85	—0.0312
*05.70	—0.0037	16.90	—0.0319
*05.75	—0.0024	16.95	—0.0463
05.80	—0.0181	*17.00	—0.0051
05.85	—0.0268	17.05	0.0253
05.90	—0.0381	17.10	0.0175
05.95	—0.0415	17.15	0.0662
06.00	—0.0446	17.20	0.0901
06.05	—0.0515	17.25	0.0859
06.10	—0.0593	17.30	0.1230
06.15	—0.0606	17.35	0.1299

*Thermally near neutral condition.

Transition in terms of sign of the gradient is sometimes related to solar transition, but may occur at other instants also. On some dates it happened that the stability oscillated for quite some time of the day and then the transition was smooth after some hours. In that case the later transition was taken as smooth transition. Table 1 shows representative thermal transitions during sunrise and sunset. It is interesting to note from Table 2 that the transitions occur around sunrise and sunset for the first four dates, around sunset only for the next two dates and at neither sunrise nor sunset for last four dates.

TABLE 2

z_0 at near neutral situation

Julian date	Time (hr)	z_0 (m)	Remarks
147	06.45	0.0335	
	16.75	0.0158	
148	05.70	0.0284	
	17.00	0.0341	
151	07.15	0.0221	
	—	—	
155	05.20	0.0282	Mean z_0 is 0.02756 m standard deviation is 0.0061
	16.00	0.0230	
156	03.65	0.0245	
	16.55	0.0381	
157	08.75	0.0207	
	18.70	0.0257	
158	01.00	0.0393	
	16.45	0.0230	
159	00.35	0.0251	
	20.95	0.0274	
160	02.05	0.0347	
	20.25	0.0244	
161	03.45	0.0296	
	20.45	0.0260	

z_0 values evaluated in different dates following the above mentioned principles are presented in Table 2. It is obvious that the values of z_0 are quite consistent with reasonable standard deviation.

So one can conclude that the roughness length at Kharagpur Micrometeorological Tower site during monsoon onset phase is around 0.03 m. In fact this value is quite consistent with the range of 0.2 cm to 9 cm given by Sorbjan (1989) for short grass terrain.

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