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EXTRAPOLATION OF THE VERTICAL TEMPERATURE PROFILES DURING NOCTURNAL RADIATION INVERSION FROM SCREEN TEMPERATURE

A method to extrapolate the temperature profile from screen air temperature based on a theory desribed by Anfossi *et al.* (1974) is presented. Experimental evidence shows the technique to give a useful profile with reasonable degree of accuracy.

The nocturnal ground based temperature inversion has significant effects on the assimilative capacity of the atmosphere, and therefore knowledge of inversion characteristics are important. Usual methods of measuring a temperature profile are instrumented towers or balloon-borne sensors, which are either expensive or manpower intensive. A simple mathematical model for vertical temperature profile was developed by Padmanabhamurty and Gupta (1979) based on Anfossi *et al.* (1976) for Mathura Refinery site and found it reasonably good in winter in the absence of actual data. The purpose of this note is to examine the validity of the equation given by Anfossi *et al.* 1976 during MONTBLEX at Kharagpur, to obtain the vertical temperature profile during nocturnal radiation inversion from screen temperature.

It is generally accepted that a nocturnal temperature inversion is created by heat propagating downwards through the atmosphere and then radiated to the night sky from the earth's surface. The atmospheric temperature T thus increases upto a height z_i, the inversion 'top' defined where $dT/dz = 0$.

Many theoretical studies have been made to predict atmospheric temperature profile from gound-based measurements. The classical method is to assume a semi-infinite medium bounded on one side by the earth's surface which is considered to radiate a constant heat flux. Under this condition the temperature profile $T(z,t)$ takes the form (Anfossi *et al.* 1974) :

$$T(z,t)=T(0,0)-[T(0,t)-T(0,0)][\exp (z^2/4\,kt)^{0.5} - z(\pi/kt)\ \mathrm{erfc}\ (z/4kt)^{0.5}] \qquad (1)$$

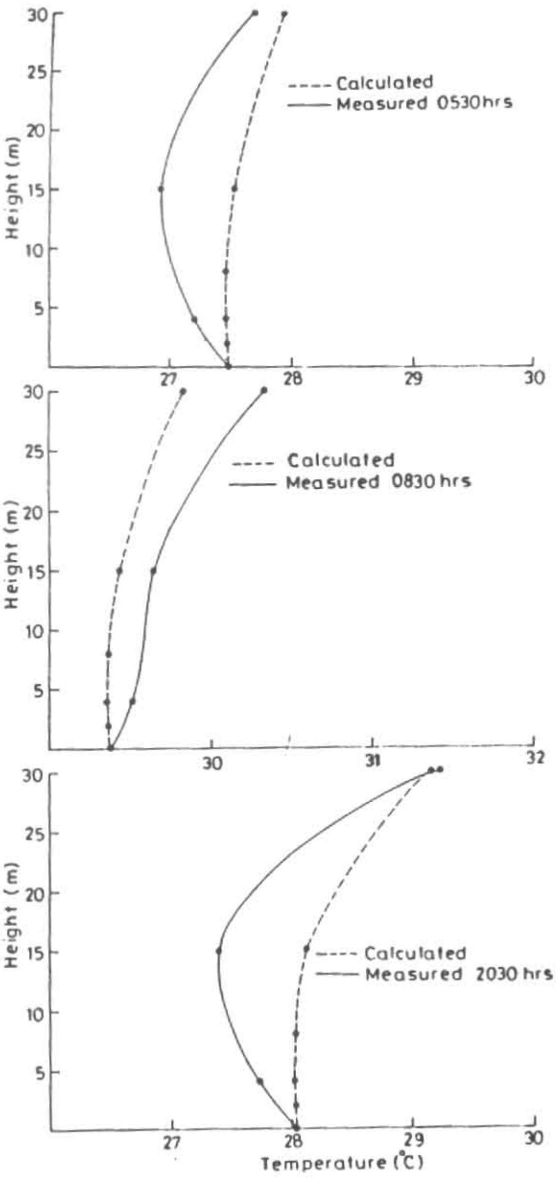

Fig. 1. Comparison of temperature profiles observed and calculated for different hours at Kharagpur on 9 June 1990

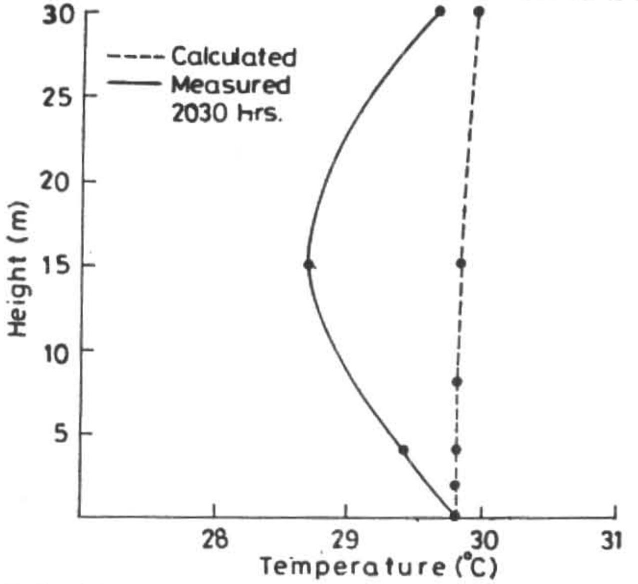

Fig.2. Comparison of temperature profiles observed and calculated at 2030 hours at Kharagpur on 18 August 1990

where z is the height above ground level, t is the elapse time in seconds since the diurnal maximum, and K is the thermal eddy diffusivity. The time origin is taken when the diurnal temperature wave reaches a maximum, *i.e.* $T(0,0)$ is the maximum daily temperature epoch at the ground.

In order to improve the accuracy of the Eqn. (1) Anfossi *et al.* 1976 modified the boundary conditions used in the above mentioned classical solution. The principal change responsible for the improvement was, instead to regarding the medium as semi-infinite, an upper bounded z_i was introduced. The atmosphere was then bounded by a fixed earth's surface and a time varying inversion 'top'. The modified solution is then given by Anfossi *et al.* 1976.

$$T(z,t)=T(0,0)-[T(0,0)-T(0,t)][\exp(-z^2/z_i^2) - (z/z_i)\pi^{0.5}\,\mathrm{erfc}\,(z/z_i)+0.278(z/z_i)] \qquad (2)$$

$$\text{where } z_i=(4Kt)^{0.5} \qquad (3)$$

This new solution showed a marked improvement over the classical solution of Anfossi *et al.* 1976. Both the above solutions are valid only for the case of non-condensation of water vapour. The condensation of water vapour at the surface has the effect of decreasing the inversion vertical temperature difference.

The temperature profile, as predicted by Eqn.(2), requires input data of the diurnal surface temperature maximum $T(0,0)$, the surface temperature at the time of the profile extrapolation $T(0,t)$, and z_i which can be computed from the time lapse since the diurnal temperature maximum and a suitable value of thermal eddy diffusivity K from Eqn. (3). The time evolution of the top z_i of the stable layer with base at ground follows a parabolic law $z_i=a(t)^{0.5}$. The numerical value for the constant a is 45, as compared by Padmanabhamurty *et al.* (1979).

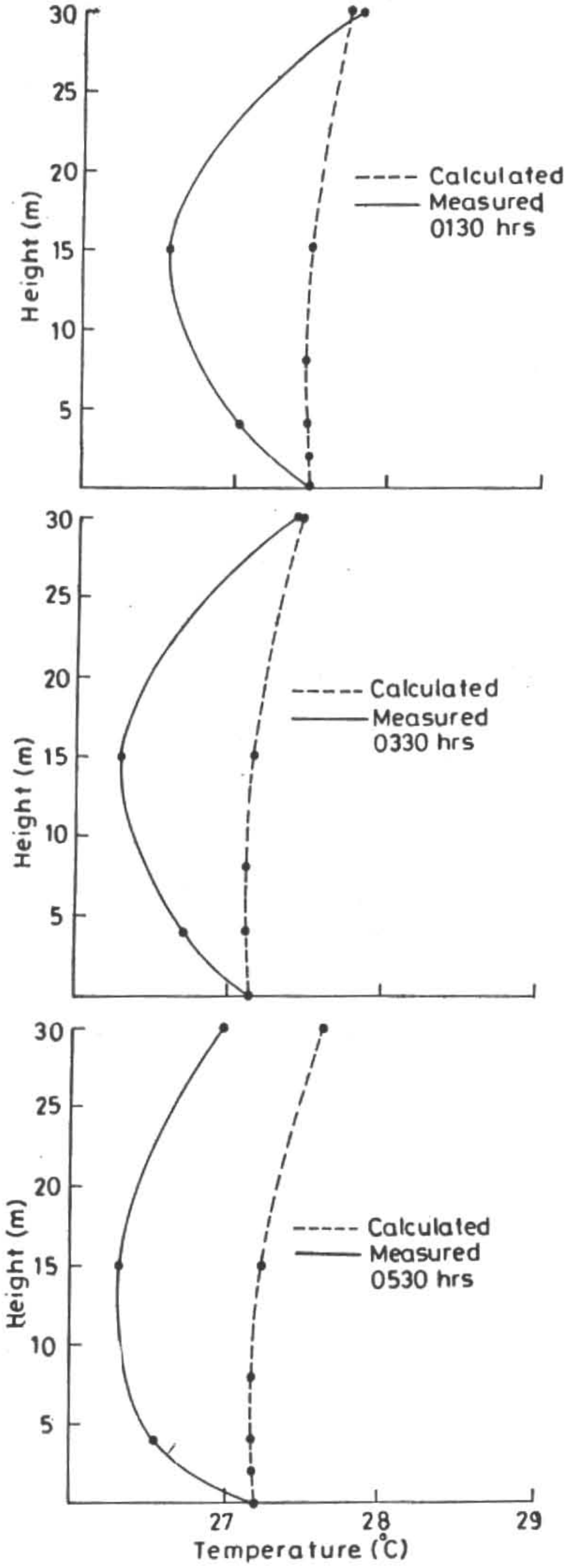

Fig.3. Comparison of temperature profiles observed and calculated for different hours at Kharagpur on 19 August 1990

In the present study a set of data collected during Monsoon Trough Boundary Layer Experiment, 1990 (MONTBLEX'90) are being analysed to develop a methodology for the evaluation of the vertical temperature profile from screen air temperature. The present data set are obtained during the monsoon time of 1990 from a 30m micrometeorological tower located at Kharagpur (22.30°N, 87.20°E).

Seven sets of profiles at different times obtained during the nocturnal period are shown in Figs (1-3). The observed profiles are shown by solid lines. The dashed lines are the predicted profiles calculated by the technique derived from Anfossi assuming his value of $K=3\times10^3 \text{cm}^2/\text{sec}$. Temperature distributions $T(z, t)$ evaluated from Eqn.(2) have been compared with the MONTBLEX data obtained from tower at 1,2,4, 8, 15 and 30m heights. On 9 June which is the representative of onset period, at 0530 hr, 0830 hr, and 2030 hr the predicted temperature differs with observed temperature by 1°C, which is shown in Fig.1. During the monsoon season, 18 August, the predicted temperature at the bottom and the top is almost same as observed but at the middle the temperature difference has come out to be approximately 1-5°C at 2030 hr (Fig.2). Similarly on 19 August (monsoon season), the predicted temperature difference is near about 1.2°C as compared with observed at 0130 hr, 0330 hr and 0530 hr, which is shown in Fig. 3.

Results have shown that the predicted temperature profile is comparable only in trend but not in magnitude with the measured temperature profile at close intervals within 30m. The temperature extrapolation procedure described (Anfossi *et al.*, 1976) here is able to infer inversion characteristics from ground-based data upto 30m level with a reasonable degree of accuracy but not point to point temperatures at closer intervals within 30m.

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